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ANTIBIOSIS[1]

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The term antibiosis, which is the title of this paper, may to many biologists be a rather new term that has been in frequent use only since the discovery of penicillin in 1929. But in reality it is a term used by botanists for a long time. It seems to have been coined by H. M. Ward (1) in an article on Symbiosis published in Annals of Botany in 1899. The more familiar term "symbiosis" has long denoted the partnership of two organisms, often of different type, for their mutual benefit. An example is the common root tubercle bacteria which live in the nodules on the roots of peas, clover, etc. Here the bacterial cells get a favorable place to live and in turn their work of storing up compounds of nitrogen, later enriches the habitats of their hosts. In the article referred to above Ward said, "Where one of two associated organisms is injuring the other . . . this state of affairs has been termed antibiosis."

This harmful relationship was studied more thoroughly by the German writer, J. Behrens (2), in 1904 in a paper entitled "Alteration Effects between Different Organisms," which appeared in the Handbook for Technical Mycology at Jena. In this article Behrens discussed symbiosis, metabiosis and *antagonism* between organisms. Dr. Erwin F. Smith (3) of the U. S. Department of Agriculture in 1905 published studies along similar lines in his article, "Bacteria in Relation to Plant Diseases." The earliest detailed work done on this subject was done in the 1890's by a French bacteriologist, C. Bouchard, and others in Europe. The entire literature in the field has recently been surveyed by Dr. Selman A. Waksman (4), the discoverer of streptomycin, who has been extremely kind and helpful to me in the preparation of this paper. He and his colleagues at Rutgers have reviewed over 1,000 articles dealing with antibiosis and I shall quote briefly the chief references in this early work. "Bouchard (5), Emmerich and Low demonstrated that certain bacteria belonging to the *Bacillus pyocyaneus* group have the capacity of inhibiting the growth of other bacteria and of actually killing these organisms. This was found to be due to the production of a substance designated as *pyocyanase*, the first antibiotic substance ever described. However, this phenomenon was looked upon rather as a freak, the substance being regarded as an enzyme that had the capacity of bringing about the lysis of certain bacterial cells. The plant pathologists constantly observed in their cultures of fungi and bacteria, the detrimental action of one organism upon another, but they were satisfied to designate this phenomenon as one of "staling" without attempting to uncover the manifold reactions involved. The soil microbiologist, in his studies of mixed populations of micro-organisms, long recognized the fact that one organism may affect, to a marked degree, the activities of another, but he dealt with such a highly heterogenous medium, the soil, that his problem appeared

[1]Presidential address, delivered before the Ohio Academy of Science at Marietta, Ohio, May 2, 1947.

hopelessly complex. By designating as "soil toxins" the injurious substances thus produced he failed to succeed in unravelling further the complicated reactions involved. The chemist isolated and even crystallized certain antimicrobial substances produced by bacteria, such as *pyocyanin* and by fungi such as *penicillic acid* and *gliotoxin*, but even then the practical utilization of these substances was hardly comprehended. Only isolated investigators recognized the great possibilities involved in the antagonistic inter-relations among micro-organisms and drew attention to their possible applications. This was first done by Pasteur and Joubert in 1877, followed by Cantani in 1885, by Bouchard, Emmerich and Low in 1889, by Vaudremer in 1913, by Much in 1924, by Fleming in 1929 and finally by Dubos in 1939. It remained for the last half decade to uncover the great potentialities of this highly important field of microbiology with its many phases touching upon Chemistry, Physiology, and Chemotherapy." In concluding this review of the history of antibiotics, I might say that the last named student in this field, Dr. R. J. Dubos, a colleague of Waksman's at Rutgers and now at Harvard, has in the period between 1929 and 1944 published 19 papers, and Dr. Waksman himself, 38 papers, on this subject in various medical, chemical, and biological journals. This indicates the great activity in this field today.

ORGANISMS IN THE SOIL AND THEIR INTERRELATIONS

Since most of the antibiotic substances in use today as therapeutic agents have been isolated from organisms which inhabit soil, it is now appropriate to examine this complex thin layer of the earth's surface.

Waksman and his associates have made thousands of analyses of soil, both biologically and chemically. Dr. Charles Thom (6), a specialist on molds in the U. S. Department of Agriculture, has said, "a teaspoonful of soil contains hundreds of millions of bacteria, millions of actinomycetes, hundreds of thousands of mold spores, tens of thousands of protozoa and hundreds of nematode worms. In such an environment a delicate, soft-walled plant like *Penicillium notatum* needs protection comparable to a tank in human warfare."

Looking first at the chemical composition of the soil it is chiefly a mass of inorganic particles of sand, clay, and pulverized rock, which constitutes 90 to 99 per cent of its volume. The organic matter in the top layer of soil varies from 1 to 10 per cent, although in dry desert and sandy soils the organic part may be less than 1 per cent and in peat and muck soils it may be increased to 50 or even 90 per cent. Contrary to what one might expect the organic or humus part of the soil is not mainly cellulose or hemicellulose which occurs in plant bodies but is high in lignin and protein content. These substances are less amenable to microbial action than the actual bodies of plants and animals. To a large degree this black mixture is soluble in alkalies and can be reprecipitated by acids. Collectively these substances have been termed "humic acids." The chief mineral components of average soils are the phosphates, sulfates and silicates of calcium, magnesium, potassium, iron, aluminum, manganese, zinc, copper and others. Some of the chemical elements derived from these minerals are utilized by organisms to make protoplasm and food such as nitrogen, sulfur and phosphorus. Others as zinc, copper, iron, manganese, boron and even potassium may serve as catalysts in life processes. The functions of these latter elements are as yet little known in the metabolism of living things. The top region of the soil in which the root systems of higher plants live is called the rhizosphere and it is in this layer that most of the biological activity of the soil occurs. It is here that the millions of organisms live as mentioned by Dr. Thom. Most of these microbial organisms are supported by the wastes or debris of the bodies of higher plants and animals that live on the surface of the earth. Some of the minute forms of life, living in the soil, are also dangerous enemies of the higher organisms that are on the surface. These are

exemplified by the root-rots, blights and wilts that attack crop plants as well as bacteria and fungi that can attack animals and men as the tetanus and botulism organisms, pathogenic yeasts and molds. Certain pathogens which normally live only in the bodies of higher animals may temporarily live in the soil having been deposited there with wastes. These may later reinfect other animals. Waksman classified the microbial denizens of the soil into eight groups, viz.: bacteria,

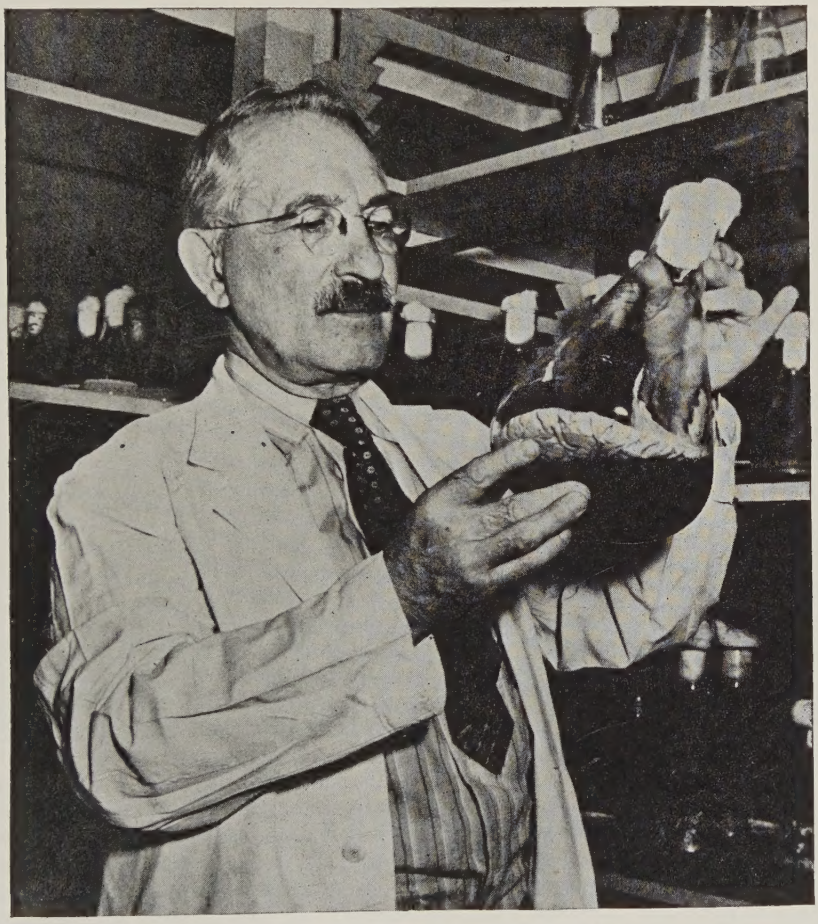

FIG. 1. Dr. Selman A. Waksman.

actinomycetes, fungi, algae, protozoa, worms, insects and near-microscopic forms, and ultra-microscopic forms such as viruses and phages.

The relative abundance of the above organisms is dependent on the nature of the soil, the amount of organic matter in it, the oxygen supply, the moisture content, the temperature, and the buffer capacity—and also the type of the higher plants growing in the area. The bacteria, actinomycetes and true fungi run into the thousands per gram of soil. Algae are numerous only in the surface layer of soil. Protozoa are found in the active state or in the form of dormant cysts. This depends on the moisture content. Sometimes the protozoa only are in the

active stage for a few hours during excessive moisture while the encysted forms occur almost uniformly in dry soils. The commonest protozoa in soil are the flagellates which may reach a population of a million individuals per gram of soil, the amebae are next in abundance and the ciliates, the fewest, numbering a few hundred to several thousand per gram of soil. The nematode worms, rotifers, earthworms and insect larvae are usually abundant.

The bacteria are of various types based on their nutrition, respiration and motility. They may be autotrophic, heterotrophic, aerobic or anaerobic,motile and non-motile, pathogenic and saprophytic, symbiotic and non-symbiotic, antagonistic and non-antagonistic. The fungi are classified into three types: saprophytic and free-living, mycorhiza-producing, and plant pathogenic. The commonest genera of soil fungi are these: *Rhizopus*, *Mucor*, *Penicillium*, *Aspergillus*, *Trichoderma*, *Fusarium*, *Cladosporium* and *Cephalosporium*. There are also numerous yeasts and fleshy or mushroom types of fungi. The mycelia of these latter fungi spread extensively through the soil and hold it together in masses.

It is now recognized that all the higher plants and animals suffer from the ravages of microbes such as bacteria, fungi and protozoa; and the more highly evolved the plant or animal, the more numerous are its microbial parasites. Many of these disease-producing agents are closely related to harmless forms which lead independent lives in soil or water. This leads to the assumption that the disease-producing agents were once non-pathogenic but which became adapted to a parasitic life in specific hosts. In such hosts these agents produce toxic substances which injure the host for a greater or shorter period until the host succeeds in building up a resistance to the pathogen or it is finally killed by it. If the host survives the attack, however, without killing its parasite, it may regain a normal life but is henceforth a carrier of the pathogen. These disease-producing organisms spread from host to host through natural media as water, dust or excreta of the host and so reach the soil or water.

When one takes into account the great length of time that plants and animals have lived on the earth and the millions upon millions of disease-producing organisms which caused their deaths and then passed into the soil and water with their disintegrating host, it would be logical to conclude that the soil and water of the earth are the great repositories of disease-producing microbes. This was the opinion of the scientists of the 19th century. But careful investigation of soils and waters show that only a few forms which would attack men or animals live in these media. It was furthermore found that pathogenic organisms that kill their hosts, when followed directly into the soil or water, do not live long and disappear rapidly. Researches on soil showed that if it is actually sterilized and then some pathogens inoculated into it, they may flourish there, but if these same pathogens are planted in fresh soil, they die quickly. Thus it is seen that the natural soil and water of the earth are not great repositories of disease-producing organisms but that just the opposite prevails. Ordinary soil by reason of its own normal microbial population destroys any pathogens which find their way into it. It has been found that even the common *Rhizobium*, a bacillus that forms nodules on the roots of leguminous plants, cannot thrive outside the nodules of the roots. Waksman (7) found that the normal soil microbes will quickly kill it when it is placed alone in soil. It survives only when protected in the security of its nodules on the plants. Another instance is the case of the Texas Cattle Fever organism. This lives in pastures of the southern states. Smith and Kilbourne (8) showed this organism to be a protozoan which is inoculated into the cattle by a tick which is a carrier for the parasite. This protozoan is not able to live in climates which are cold enough to kill the ticks. Thus it is seen that it cannot survive in the soil of the pasture unless it is protected in the body of the tick.

ORGANISMS PATHOGENIC FOR MAN

Briefly at this place let us pause to look at the micro-organisms which may produce diseases in man. These small forms are found in both the plant and animal kingdoms. In the latter belong the Protozoan parasites which infect man inside his body or on the surface. In this group fall the amebae, which live in his intestine or in the mouth, the malaria which devour his red corpuscles, the flagellates which may live in the genital tract or the trypanosomes that cause sleeping sickness in nervous tissues and the ciliate, *Balantidium*, that infects the colon. But by far the greater number of his ills are due to plants which are parasitic members of that great group comprised under the vague term of Mycetes or Fungi. This poorly

FIG. 2. Streptomycin crystals. (× 350.)

defined and mixed aggregation includes the Schizomycetes or Fission Fungi and the Eumycetes or True Fungi. The Schizomycetes are made up of three smaller groups; 1, the Eubacteriales or True Bacteria; 2, the Spirochaetales; and 3, the Actinomycetales. The True Bacteria are now pretty well defined and contain most of the familiar bacilli, cocci, and spirilla. The latter contains the *Vibrio* that causes Asiatic Cholera. The second group, Spirochaetales, may have descended from protozoa. It includes the Syphilis organism, *Treponema*. The third group, Actinomycetales, is supposed to have descended from the true fungi, are called the Higher Bacteria. One division of it—the Mycobacteria—includes the organisms that produce tuberculosis, leprosy, and diphtheria. The other division of the Actinomycetales consists of harmless soil organisms, some of which furnish antibiotics like streptomycin.

Associated with the True Bacteria are the Rickettsias, which seem to be very small forms that may have evolved from regular bacteria and have become pasasites such as cause Typhus Fever and Rocky Mountain Spotted Fever. Besides these there is the large group of viruses. These are so small they can pass through

fine porcelain filters and bacterologists have not determined whether they themselves are organisms or some product of organisms like enzymes. They differ in character from bacteria and fungi but are definite entities which produce such diseases in man as rabies, smallpox, yellow fever, parrot fever, chickenpox, German measles, mumps, infantile paralysis, influenza and common colds, and herpes or cold sores. These viruses are smaller than rickettsias and cannot be grown on culture media unless living cells are also present. They multiply only in young living susceptible cells, where they live like intracellular parasites. Their presence is indicated by tiny particles of uniform size in the cytoplasm of the cells. These are called inclusion bodies of virus bodies and have been isolated by centrifugation and studied in the production of vaccines.

Before leaving the subject of classification of pathogenic organisms it will be well to mention an artificial classification in the true Bacteria which divides them all into two important physiological classes. These two artificial groups are formed by a simple staining technic used by bacteriologists called Gram's Stain. A dried film of bacteria on a glass slide is stained with a violet analine dye, next this is treated with a solution of iodine and iodide. The dye is removed by immersion in alcohol to a state colorless to the naked eye. It is washed with water and counterstained with a pink or brown dye. Upon examination under a microscope the bacterial cells will appear either violet due to the first stain or pink or brown with the counterstain. The difference in this staining behavior in different types of bacteria is due to the peculiar composition of the protoplasm of the cell and its interaction with the reagents employed. Bacteria of a protoplasmic type which retain the violet stain are said to be Gram-positive and those which do not hold it but instead take up the pink or brown counter stain are called Gram-negative. In subsequent discussion of antibiotics there is a sharp distinction in their reactions to these substances by gram-positive and gram-negative bacteria. Some antibiotics are antagonistic to only one of the two groups of bacteria and some can inhibit both sorts.

THE NATURE OF ANTIBIOTICS

The various chemical compounds called antibiotics have certain properties which differentiate them from common antiseptics and disinfectants. In the first place, they are produced by living organisms, although recently penicillin has been synthesized directly from non-living chemicals. Antibiotics in general may have merely an inhibitory effect on the growth of bacteria or they may actually destroy them by a complete dissolution called lysis. Waksman classifies antibiotics in the broad sense as any substance which may produce the two effects above mentioned on bacteria. These antibiotics may be products of higher plants, like quinine from the Chinchona tree, certain proteins of wheat flour, the oils in onions and garlic which kill not only bacteria but as Professor B. P. Tokin (9) of Russia showed in 1944 may kill higher organisms like yeasts. He calls these antibiotics *phytoncides*. Likewise in 1944 Cavallito (10) and Baily of Rensselaer, New York, showed that the juices of burdock, butter-cup, dog-tooth violet and wild ginger, all contained similar antibiotic substances. These men showed also that the amino acid, cystine, inactivated these phytoncides and also the antibiotics derived from the lower organisms such as molds, like penicillin and streptomycin. In January, 1947, Dr. Alfred Marshak of the U. S. Public Health Service, reported an antibiotic for the tuberculosis organism derived from an epiphytic lichen which grows in California, *Ramalina reticulata*, called Spanish Moss. Its yellow crystals retard tuberculosis in experimental animals and appears to be non-toxic. Waksman includes in the broad sense antibiotics derived from animals such as lactenin and lysozyme found in tears and perspiration. But more specifically the therapeutic antibiotics refer to the antagonistic substances produced by micro-organisms. In 1903 Krenckner

(11) noticed that the culture filtrates of bacteria inhibited the growth of bacteria. It is now known that certain bacteria, fungi and actinomyces do produce these substances. These antibiotics are very selective in their action. They affect chiefly the gram-positive bacteria and to a lesser extent the gram-negative bacteria and a few antibiotics can inhibit the growth of both types of bacteria—each antibiotic thus has its own bacteriostatic spectrum. Their production is determined by the strain of the organism, the composition of the culture medium, the temperature of incubation, the age of the culture and the aeration. The antibiotics vary greatly in their action on bacteria, their toxicity to the animal in which the

FIG. 3. Sir Alexander Fleming.

bacteria live and in their practical uses in treating disease. Thirty-seven or more of these antibiotics have been isolated and studied for their chemical properties and their biological activities. A few of the commoner ones are discussed here. *Actinomycetin* from *Streptomyces albus* is soluble in water but precipitated by alcohol, is thermolabile and protein in nature; it is lytic to dead gram-negative bacteria and to some living gram-positive forms. On the other hand, *actinomycin* is secured from *Streptomyces antibioticus*. It is soluble in ether and alcohol, insoluble in petrol ether; orange colored; thermolabile and is lytic for gram-positive bacteria and in higher concentration for gram-negative bacteria and is highly toxic to animals. Here then are two antibiotics from closely related soil organisms but with quite different properties. *Aspergillic acid* is derived from *Aspergillus flavus*, a fairly common mold. It is soluble in water, alcohol, ether and acetone but insoluble in petrol ether. It is acid in nature and is lytic to both gram-positive and gram-negative bacteria. Another antibiotic is *clavicin*, *clavitin* or *patulin* which is formed in several species each of the molds *Aspergillus* and *Penicillium*. It is soluble in ether, chloroform, alcohol and water. It is lytic to both gram-positive

and gram-negative bacteria as well as fungi. It is highly bactericidal but is toxic to animals. *Flavicin, flavitin, aspergillin* or *parasitin* is a substance produced by three different species of the mold *Aspergillus* and in all its characteristics is similar to the antibioltic *penicillin. Gramicidin* is an antibiotic isolated from *Bacillus brevis.* It is a polypeptide and is thermolabile; soluble in ether and alcohol; lytic to gram-positive bacteria but is hemolytic in the bodies of animals. The common mold *Penicillium,* in at least four or five species, produces several antibiotics. The most famous is *penicillin.* Others are *penicillic acid. penicidin, notatin* and *mycoin. Penicillin* is isolated from *Penicillium notatum;* soluble in alcohol and water and in ether at pH 2; thermolabile and lytic to gram-positive aerobic and anaerobic bacteria and of low toxicity in animals. Still other antibiotics are *streptomycin* and *streptothricin,* both derived from two different species of *Streptomyces,* an Actinomycete genus. They are both soluble in water and in acid alcohol, insoluble in ether. They behave like organic bases and are thermostable. *Streptomycin* is lytic to gram-negative bacteria and of low toxicity in the bodies of animals. *Streptothricin* is lytic to gram-negative and some gram-positive bacteria and has a higher toxicity in animals. *Bacitracin* (12) is another new antibiotic isolated from strains of *Bacillus subtilis.* It is water soluble, thermostable and acid stable, non-hemolytic, non-stable in alkali, resists digestion by pepsin and trypsin and is non-toxic in animals. *Subtilin,* also derived from *Bacillus subtilis,* is soluble in alcohol and is stable to heat and acid but unstable in alkali. It is lytic to both gram-positive and gram-negative bacteria and slightly toxic to animals. *Chlorellin* (13) is an antibiotic derived from a green alga, *Chlorella vulgaris.* It is antagonistic to the same groups of organisms that are susceptible to penicillin but has the added advantage that the alga is much simpler to cultivate than fungi, needing only water, a few mineral salts and an adequate amount of carbon dioxide blown through the culture. Of all the thirty-seven or more antibiotics discovered, only *penicillin* and *streptomycin* have come into wide general use and to a lesser extent *bacitracin* and *chlorellin.*

We will now discuss the discovery and manufacture of these two new and dramatic drugs.

First I should like to relate an example of natural antibiosis that occurred in my own observation. About four years ago in Toledo a friend of mine was troubled with an infection of "athlete's foot" fungus on his leg. He consulted a dermatologist who treated it with drugs and X-ray therapy but the infection was slow to heal. After several months, my friend had the misfortune to break his leg in a traffic accident and was hospitalized. While in the hospital he contracted erysipelas severely on his back and legs. This was treated by routine methods and in a short time was cured but the "athlete's foot" fungus which had been living in the area of skin attacked by the erysipelas had also entirely disappeared. This was a natural case of antibiosis in which the *Streptococcus* organism of erysipelas had destroyed the fungus *Trichopyton* which caused the "athlete's foot" disease.

The discovery of penicillin occurred in 1929 by Dr. Alexander Fleming, now Sir Alexander Fleming, while working at St. Mary's Hospital in London with some culture plates of *Staphylococcus aureus.* He noticed that in a plate which had become contaminated by a mold spore, the area around the mold mycelium showed a clear zone where the *Staphylococcus* had disappeared. He cultured some of this mold in broth to see if it had really killed the bacteria. In later experiments he found that if he took a drop of the broth in which the mold, identified as *Penicillium notatum,* had grown and placed it on a living culture of *Staphylococcus,* as the broth spread over and through the agar on the plate, it would kill off the bacteria. Dr. Fleming discovered that several varieties of *Staphylococcus* were susceptible to the substance in the broth and still later he learned that the bacteria causing boils, diphtheria and abscesses with pus formation could be entirely inhibited by the

broth in which the mold *Penicillium* had grown. On the other hand, he learned that the colon bacillus from the normal intestine and organisms which cause typhoid, dysentery and influenza were not affected at all by the broth substance.

Next he injected the broth into animals and found that they were no more irritated than if pure sterile broth had been used. In the British Journal of Experimental Pathology (14) in 1929 he modestly suggested that perhaps this antibacterial substance in the broth might be used clinically to help infections caused by the bacteria which he found susceptible to it. Since the mold which produced the antibiotic was *Penicillium*, he called the substance *penicillin*. For ten years this antibiotic excited little interest in the world: First, because it was a very unstable

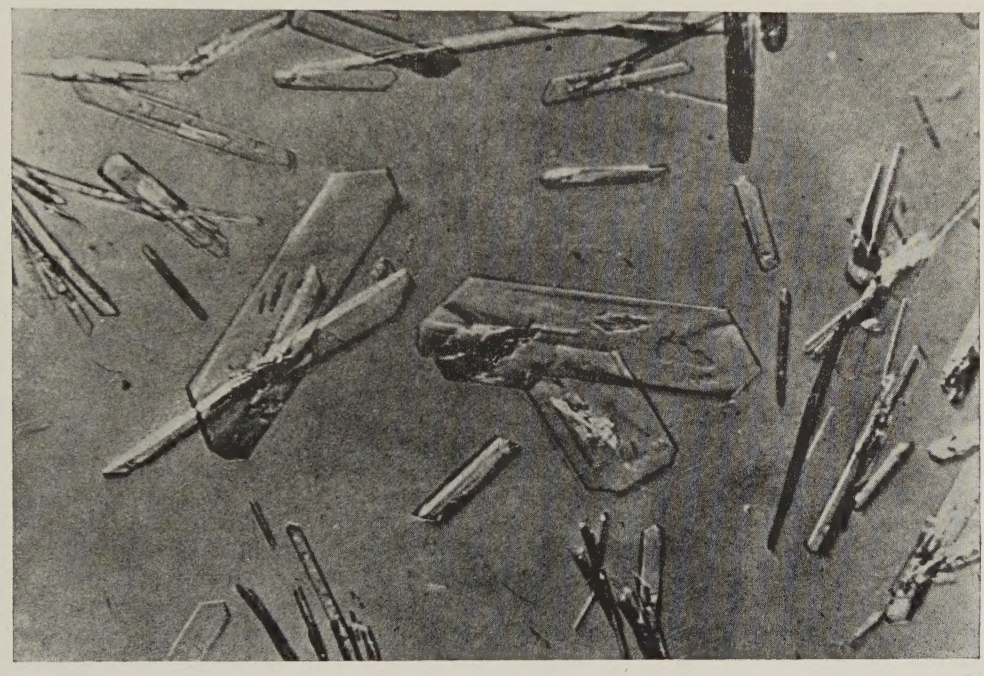

FIG. 4. Penicillin crystals. (× 500.)

substance and second, it could be produced only in very small amounts. During these ten years Dr. Fleming wrote several articles in which he used penicillin to differentiate various strains of bacteria. In 1931 Clutterbuck (15) and others told in the British Biochemical Journal that they were successful in growing the mold in larger amounts and had worked out the features of penicillin chemically. In 1943, Dr. H. W. Florey (16) and others in the "Lancet" described the use of penicillin as very effective in checking infections and that it had a low toxicity in the human body.

Just prior to this, in 1939, Dr. R. J. Dubos (17) in the Journal of Experimental Medicine announced the isolation of some bacteriocidal fractions from the culture media in which had been grown the soil organism *Bacillus brevis*. These substances were classified as polypeptides and were named *gramicidin* and *tyrocidin*. They were clear colorless crystals and were antagonistic to a number of bacteria but clinically they were not useful on account of the relatively high toxicity to the patient.

In 1940 and 1941 Florey and his co-workers reported in some 300 papers their results in treating several hundred patients in England with penicillin. In 1941 the interest in the drug became general and Professor Florey was invited to this country by the Rockefeller Institute to attempt a large-scale production of penicillin which was then impossible in England due to the bombing and devastation of the war. Our National Research Council and the Northern Regional Laboratory of the U. S. Department of Agriculture at Peoria, Illinois, and several large pharmaceutical firms all co-operated to make large-scale production possible.

At first the yield of penicillin was only two units per milliliter of culture medium. This was not fast enough since a million units are necessary to treat a deep seated infection. The next important step was the discovery by Dr. Andrew Moyer at the Northern Regional Laboratory that a by-product of the corn refining industry, called corn-steep water could be used as an ingredient in the culture medium in which to grow the mold. When this was added, it increased the yield of penicillin to more than forty units per milliliter of fluid.

All penicillin is now produced from a highly selected strain of *Penicillium notatum*. This mold grows most anywhere on decaying vegetables, dairy products or in the soil but a strain in a special collection called the Type Culture Collection in Washington, D. C., is labeled N. R. R. L. 832. This was found growing on a piece of decaying cantalope. This strain is the best known producer of penicillin. Penicillin made from unknown or wild strains of *Penicillium* have been found to induce severe anaphylactic symptoms and allergy in patients with high fever. Commercial penicillin is now carefully treated to eliminate any such dangerous proteins.

In the manufacture of penicillin the chief difficulty is to insure sterility of the cultures. It is a strange thing that this antibiotic which is a potent killer of numerous bacteria is itself killed by some of the bacteria which it cannot conquer. Therefore, it must be cultured under the most rigid aseptic conditions. The ordinary colon bacillus which is not inhibited by penicillin produces such a potent enzyme for the destruction of penicillin that it is called penicillinase by Abraham and Chain (18).

The optimum temperature for the growth of *Penicillium* is 24° C. The source of the carbon for its nutrition is lactose and the source of its nitrogen is sodium nitrate. Zinc ions seem also to be necessary for its production. The composition of corn-steep water which so greatly increases the yield of penicillin is not entirely known but in a recent article by Gregory Schwartzman in *Science* he showed that if cellophane is suspended in the culture medium, it also increases the yield of penicillin. It may be then that corn-steep water, a by-product in making glucose and corn-starch may contain a cellulose derivative similar to cellophane.

Since the *Penicillium* mold is an aerobe, it must have an adequate supply of oxygen. The aeration of the culture then had to be solved. Three devices were used to secure aeration. One was the surface method. This older method was to grow the mold in flat half-gallon bottles or flasks. The films of mold were floating in culture medium not more than 2 cm. deep. Aeration was thus by simple diffusion. In this method contamination of the bottles with foreign organisms was a great danger. A second method was the bran method. In this method coarse bran was spread in large trays and the mold culture was sprayed on the bran and after the usual growth period the penicillin was extracted from the mass. The third method is the Submerged Culture Method and all the large plants now use this procedure. The mold is grown in high cylindrical tanks each holding 1,000 gallons. Aeration is brought about by a vigorous bubbling of sterile air through the mass in the culture tanks. The yield per milliliter by this method is slightly less than culture in bottles. The only problem in the Submerged Method is to insure the complete sterilization of the large volumes of air needed to be blown

through the tanks. By 1945 the combined output of twenty-one companies making penicillin was 200 billion units per month or about nine pounds of penicillin per day.

The method of extracting the penicillin from the culture medium is as follows: The pH of the fluid is adjusted to 1.9 or 2 with phosphoric acid. It is then agitated with a solvent that is immiscible with water, such as amyl acetate or chloroform. After separation of this solvent the aqueous part is discarded. The amyl acetate containing the penicillin in acid form is shaken up with a little water containing sodium bicarbonate. This converts the penicillin to the sodium salt. The sodium salt of penicillin is further purified by adsorption on columns of alumina or with activated charcoal. It is now chemically usable but it is considered desirable to remove traces of amyl nitrate that might be left, so the sodium salt is usually filtered through Seitz bacterial filters and dried by sublimation from a frozen state under reduced pressure. The product is a yellow powder which is quite stable when perfectly dry and is best kept in a refrigerator. When needed for use it is merely dissolved in water or in a normal saline solution.

ASSAY METHODS FOR PENICILLIN

The strength or concentration of penicillin is measured by a bioassay method which depends on its antibiotic properties. The unit was devised by Professor H. W. Florey and M. A. Jennings (19) and is called the Oxford unit. It was published in 1942 in the British Journal of Experimental Pathology. The Oxford unit is now the standard for this drug. It is the amount of penicillin dissolved in 50 ml. of meat extract broth which will just inhibit the growth of a test strain of *Staphylococcus aureus*. Thus a preparation of penicillin which will just inhibit the test strain of the coccus contains one unit. With a dilution of 1 : 50,000 the technic of making the assay is by the cup method. The standard coccus No. 209 is grown on a petri dish and in it are set five small porcelain cups. In two of these cups is placed a standardized solution of penicillin of one unit strength per milliliter. Into the other three cups is placed some of the penicillin solution whose assay is being made. The plates are incubated over night. In the morning the examination of the clear zones around each cup where the penicillin has penetrated the agar and killed the coccus is made. Comparisons of the widths of the zones of the known strength with those of the unknown is the basis of the assay. Pure crystallin penicillin has a standard assigned strength of 1650 units per milliliter or stated in another way 0.6 grams of penicillin has an antibiotic activity of one million Oxford units. The uses for which penicillin is indicated will be given later.

The story of the other important antibiotic, *streptomycin*, began with the search for some antagonist to the gram-negative bacteria. Penicillin combats effectively against the gram-positive forms. But against the gram-negative pathogens of typhoid, colon bacillus infections, dysentery, undulant fever and tularemia and the acid fast bacteria such as *Mycobacterium* which causes tuberculosis, it is impotent. In 1939 the Department of Microbiology at Rutgers University began to study antibioltic substances and under the leadership of Dr. Selman A. Waksman (20) they isolated seven compounds. These are: 1, *actinomycin*, which was found to be highly toxic to animals; 2, *clavicin*, which was active against gram-negative bacteria but also toxic; 3, *fumigacin*, not so toxic but also not very active; 4, *chaetomin*, which was non-toxic but also ineffective in animals; 5, *micromonosporin*, which held little promise; 6, *streptothricin*, which was effective as an antibiotic but still toxic to animals; and finally 7, *streptomycin*. This last substance was isolated from an actinomycete. These are microbial organisms between bacteria and fungi which form thread-like growths in the soil. The organism is named *Streptomyces griseus* and was isolated twenty-eight years previously, (21) as an organism living in soils and composts. In 1939 Dr. Waksman and his colleagues secured two cultures of this actinomycete. One from a heavily manured field near Rutgers

and the other from the throat of a chicken. The *Streptomyces* was grown on a liquid medium which, to produce the best results, contained the elements of meat extract. The carbon nutrients could be supplied by starch and glycerol and the nitrogen from casein and sodium nitrate. The final culture medium adopted was composed of glucose, peptone, meat extract, sodium chloride and water with a pH of 6.5–7. If a culture is shaken, the growth is more rapid, a maximum growth being attained in two to three days. In stationary cultures the maximum growth requires nine days. In either method the culture medium becomes alkaline. The strains of *Streptomyces* are not quite constant but in general they undergo very little variation under cultural conditions. For the most part highly potent strains retain their potency and poor strains remain weak producers of streptomycin. The streptomycin is formed equally well in stationary or submerged cultures. Streptomycin is water soluble and may be easily isolated from the culture medium.

When the broth culture has attained its maximum antibiotic activity, the incubation is terminated and the mass is centrifuged or filtered to separate the broth. The selection of the filter is important since streptomycin is rapidly adsorbed on various filters. The filtered fluid is alkaline and is next treated with activated charcoal which completely adsorbs the streptomycin. The charcoal adsorbate is centrifuged or filtered off and washed with alcohol to remove impurities. Then it is treated with dilute acid aclohol to bring the streptomycin into solution. The acid alcohol solution is then neutralized and filtered to remove any final impurities that have precipitated out. The resulting solution is concentrated by adding ten volumes of ether which takes up the alcohol and leaves the streptomycin as a yellow, brownish or reddish aqueous concentrate. By precipitation with acetone or by dessication in a vacuum, solid streptomycin is obtained. A more pure form can be obtained by the addition of methyl orange, which is the sodium salt of helianthine. The resultant crystals are streptomycin-helianthate from which soluble salts of streptomycin can be obtained. Another method of obtaining purer salts is by precipitation of the charcoal adsorbate with phosphotungstic acid and picric acid. Reinecke salt is added to the aqueous solution which forms crystalline precipitates and by fractional distillation pure streptomycin reineckate is obtained. These are then converted to either the hydrochloride or the sulfate of streptomycin.

STREPTOMYCIN ASSAY AND UNIT STRENGTH

The assay of streptomycin may be done in various ways as the agar dilution streak, or the agar cup method or the turbidimetric method. The original unit was determined by the amount of streptomycin in one milliliter of nutrient broth which will just inhibit a given strain of *Escherichia coli*. This was called the S unit. Since this unit is so small, it was found to be more convenient to use the antibiotic in one *liter* of broth instead of a milliliter, hence this unit is called the L unit. In dealing with the pure crystalline material it was found that 1,000 L units or 1,000,000 S units could be approximated closely by dry weight, so now the G unit is used which is one microgram of dry crystalline streptomycin. In a comparison of the Oxford units of penicillin and the G units of streptomycin it must be remembered that they have no similar basis. In dry weights of the two antibiotics one streptomycin unit is one microgram whereas an Oxford unit of penicillin weighs only 0.6 microgram. The bacteria used in the two assays are also quite different, *Staphylococcus aureus* being gram-positive and *Escherichia coli* being gram-negative.

In contrast to penicillin, streptomycin is remarkably stable both chemically and biologically. The latter can be stored in a refrigerator for six months without any loss of potency; also no other organisms destroy it as they do penicillin.

Bacitracin, which was discovered in 1945 by Drs. B. A. Johnson, Herbert Anker, and Frank L. Meleney at Columbia University's College of Physicians, appeared in the broth on which was cultured organisms derived from wounds.

It is formed by a type of *Bacillus subtilis*. The filtrate is extracted with butanol, concentrated by steam distillation and precipitated as a grayish white powder. It is neutral, and unlike gramicidin or subtilin, cannot be extracted with ether, chloroform or acetone. It is water soluble and non-toxic. It is active in animals and human infections against gram-positive organisms as *Streptococcus*, *Stephylococcus* and gas-gangrene due to *Clostridium*. It is used clinically by its discoverers but is not yet standardized nor commercially available.

CLINICAL USES FOR PENICILLIN AND STREPTOMYCIN

During the latter part of the recent war Dr. Chester B. Keffer, Chairman of the Committee on Chemotherapeutic and Other Agents, of the National Research Council published a report on analyses of thousands of cases treated with penicillin. This report was issued by the Office of Civilian Distribution of Penicillin.

In the discussion of the uses for penicillin as a drug the application was divided into four classes or groups:

Group I shows that penicillin is indicated for all infections due to *Staphylococcus*, as carbuncles, meningitis, sinusitis, pneumonia, wound infections and osteomyelitis; also gas gangrene due to *Clostridia;* all infections due to *Streptococcus*, such as cellulitis, mastoiditis, meningitis, peritonitis or pneumonia; all anaerobic *Streptococcus* infections as puerperal sepsis; all infections due to *Pneumococcus* in the pleura, meninges or endocardium; and all cases of sulfa-resistant *Pneumococci;* and finally all infections due to gonococci.

Group II shows that penicillin is effective but its potency is not yet clearly established in cases of syphilis, actinomycosis and bacterial endocarditis.

Group III shows that penicillin is of questionable value in mixed infections in which gram-negative organisms predominate, such as ruptured appendix, liver abscesses, urinary tract infections and Rat-bite fever due to *Streptobacillus moniliformis*.

Group IV shows that penicillin is contra-indicated because it is ineffective in all gram-negative bacillary infections of typhoid, colon bacillus, dysentery, influenza, undulant fever and tularemia. Also it is impotent in tuberculosis, acute rheumatic fever, lupus, infectious mononucleosis, pemphigus, Hodgkin's Disease, acute and chronic leukemia, ulcerative colitis, coccidiomycosis, poliomyelitis, all virus diseases and cancer.

This rather complete survey indicates the clear cut benefits of its use as well as the large area of diseases in which it is of no value at all.

Now to consider the indications for streptomycin therapy. No complete summary has yet been issued for the uses of this drug since much work is still being done upon it. In general it can be stated with reasonable assurance that streptomycin is indicated in most cases of infection that are resistant or wholly untouched by penicillin, sulfa drugs or serum therapy. According to Greey (22) of Toronto University, streptomycin is effective in chronic infections of the urinary tract due to *Escherichia coli*, *Aerobacter aerogenes* or *Pseudomonas aeruginosa*. In four to eight hours after treatment with streptomycin given intromuscularly the urine was negative for these organisms. It is also indicated for infections of the intestine due to typhoid and related organisms, via., *Eberthella*, *Salmonella* and possibly *Shigella* of the dysentery organisms. Flippin (23) of the University of Pennsylvania states that patients with twenty-three million *Salmonella* (paratyphoid) bacterial count in the stools gave negative stools after four days therapy with one gram of streptomycin given orally per day.

This drug is also indicated in systemic diseases due to *Brucella* infections such as brucellosis or undulant fever. This was recently communicated by H. A. Reimann (24).

Infections due to *Klebsiella* or Friedländer's bacillus causing forms of pneumonia and a venereal disease are definitely cured by streptomycin. A report by Heilman (25) of the Mayo Clinic last year states that patients with *Klebsiella* infections of the respiratory tract showed negative sputa in a short time.

Infections due to *Pasteurella tularensis*, the organism of Rabbit Fever or tularemia, have been treated by Foshay (26) of Cincinnati University. He reports that a patient who on the eighth day after the onset of the disease received streptomycin therapy was sent home cured on the seventeenth day after admission to the hospital, although the average duration of tularemia is three to nine months.

Perhaps the most striking application of the use of streptomycin, although still in the experimental stage, is the treatment of tuberculosis. Each day at present new reports are coming out of the trials of this drug against *Mycobacterium tuberculosis*. Feldman and Hinshaw (27) of the Mayo Clinic have treated twenty-two tuberculosis patients with streptomycin for nine months. They report that it has a suppressive effect on the disease and that its progress is temporarily inhibited. It is to be hoped that research on the use of streptomycin in combating this great white plague of civilization will continue and that it will prove to be a trustworthy chemical weapon against this disease. Only last week (April 6, 1947) U. S. Surgeon General Thomas Parran appeared before the Senate Appropriations Committee and urged that it approve a fund of one million dollars for streptomycin research against tuberculosis. Dr. Herman E. Hilleboe, in charge of the research, told a committee in the Senate that while the original cost of streptomycin of twenty dollars per gram is now reduced to three dollars per gram, even yet at the present rate it requires ten to twelve dollars' worth of the drug daily for each patient.

CLINICAL ADMINISTRATION OF ANTIBIOTICS

Penicillin may be administered intramuscularly, intravenously or into body cavities such as the pleura and the sub-arachnoid space, or locally. Some of its salts are irritating to tissues, notably the sodium salt. A constant intravenous drip injection of thirty to forty drops per minute into a vein has been found most effective in reducing acute infections. It is excreted very rapidly in the urine and two hours after an initial dose is given, it is impossible to detect it in the blood. About 40,000 to 120,000 units per day bring susceptible infections rapidly under control.

Streptomycin also may be given by intravenous or intramuscular injection. It likewise is rapidly excreted by the kidneys but by frequent injections a constant therapeutic level may readily be maintained in the blood. By oral administration streptomycin does not easily get into the blood stream and so its effectiveness is not gained by administrations through the mouth. But in the intestine it is not destroyed and its presence can easily be detected in the stools where it exerts a markedly repressive effect on the normal bacterial population of the intestine. Streptomycin given by injection may be quite painful and one symptom of its use over a period is the production of tinnitus or a ringing sensation in the ears. In some cases this is extended to deafness for a longer or shorter time following its employment.

In concluding this discussion of antibiosis I am sure that we all agree that the present decade which has made possible the applications of these miracle-working antibiotic substances has placed in the hands of man one of the most powerful weapons against disease and that the life and health of millions will be preserved by the patient studies of men like Fleming and Waksman. They will be rated in history with the great benefactors of our race.

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A NEW SYNTHETIC RUBBER

A new synthetic rubber, recently revealed by William O'Neil, president of The General Tire & Rubber Company, was one of the main topics for discussion at a recent company research panel headed by Gil Swart, General's chief research chemist.

The research experts, including professors from colleges with which General has a research arrangement and representatives from many General Tire plants, outlined plans for the new rubber that comes closer to matching all the advantages of natural rubber than anything now available. It has chlorinated styrene as its basic ingredient. News of the proposed uses for this rubber will be released soon.

A LIST OF BOOKS ON THE PERSONALITIES OF GEOLOGY

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INTRODUCTION

Geological textbooks, memoirs, monographs, and reports properly deal with the facts, principles, deductions and applications of the science of the earth. Here and there the reader or student catches glimpses of the men who gathered the facts, made the deductions, and originated the philosophical principles; or finds fragments of the history of the development of geology. But aside from this vast storehouse of scientific information, there is a small but precious number of books recording the lives of geologists, their letters, travels, and history of their building our knowledge of the earth and its past.

The writer has not seen any lists[1] of this aspect of geology,—its "human side," to overwork a tired phrase, and presents below a list of those which have come under his notice, with some annotations which may be of use to those who wish to read something about their predecessors, how they worked, their troubles and triumphs, their friends and adversaries. What geologist or enthusiast will not feel a glow of pleasure after having been, vicariously—

With the versatile Scottish editor, Hugh Miller, on the Island of Hoy, Orkney, as, wrapped in his plaid, he carved his initials of the Dwarfie Stone, under which he had sought shelter from the boreal rain; or with him and his friend the Parson of the Small Isles, as they cruised the waters of the Hebrides in the church yacht "Betsey"; or with him as he tramped the shores of Cromarty and discovered the weird fish of the Old Red Sandstone?

With the young and uncertain Charles Darwin, bitterly seasick as the "Beagle" battled her way through the Straits of Magellan towards the South Seas where first germinated in his mind the seed of evolutionary theory; or with him in Chile as he sees a rare fox intently watching officers working a theodolite and by quietly walking up behind, kills it with a blow of his geological hammer?

With the brilliant but hasty William Buckland as he crawled into Kirkdale Cavern in 1821 to discover a veritable boneyard of ancient mammal bones; or with him as he announces to his class at Oxford: "The next lecture will take place in the fields above the quarry at Stonesfield"?

With the eager young clergyman Adam Sedgwick, knowing little or nothing of geology, as he accepts the Woodwardian Professorship at Cambridge; or with him soon after as he struggles to unravel the Cambrian succession in North Wales?

With lofty-seeming but excitable Charles Lyell as he jolted and bounced by stage-coach from Cincinnati to Cleveland in 1842; or with him on his first trip to Switzerland as he walked from Chamonix over the Mer de Glace and other glaciers to Le Jardin and back—48 miles—"too much for one day"; or with him when he hired a smith to carve his initials and date on the rocks at water level on the Swedish coast so that later geologists might measure the rate of uplift; or with him again, now a baronet and the leading geologist of Britain, as he visits his queen at Osborne and expounds the Darwinian theory?

With the choleric titan of Albany, James Hall, as he took passage on the night steamer to New York and quietly threw overboard the entire edition of a geological chart on which his name failed to appear; or with him in horse and buggy, jogging

[1]There are many biographical references, especially to periodicals, in Merrill's *Contributions to the History of American Geology*, Appendix B, pp. 689–715.

over the roads of the Finger Lake region of New York, unravelling the stratigraphy of the Devonian rocks and turning out their treasure-trove of fossils from which he wrested international fame?

With the young red-bearded giant, Raphael Pumpelly, as he posted across Siberia in the dead of winter, squeezed with another passenger, a handsome and mysterious young woman, in a sledge drawn by relays of galloping ponies?

With bold and ambitious Major Powell as he launched his boats on the Colorado River at Green River City for the first trip down the Grand Canyon,—a trip from which no one expected his return?

With the wealthy bachelor, Othniel Charles Marsh of Yale and his group of adventurous students as they braved the very real dangers of the West in 1870 to plunder the vast Tertiary mammal deposits; or with him as he awaited a reply to a cablegram sent to Professor Geinitz in an effort to buy the second specimen of *Archeopteryx?*

Or with zealous Amos Eaton in 1826 as he took a party of students on a geological tour by canal boat ("The School Flotilla") on the new Erie Canal,—one of the first summer field courses?

ANNOTATED LIST

In the list below, divided into five groups: *biographies*, *journals* and *diaries*, *travels*, *histories of geology*, and *miscellaneous*, the arrangement is alphabetical by authors except for the biographies which are listed according to the name of the subject of the book. With one or two exceptions, the list includes only those which have appeared as *books*, and thus deliberately excludes the numerous short biographical notices and memoirs, and sketches which have appeared in various journals. It is certainly incomplete, and the writer will welcome additions and corrections.[2]

BIOGRAPHIES

Agassiz, A. Agassiz, G. R. *Letters and Recollections of Alexander Agassiz.* Houghton Mifflin, 1913.

Son of Louis Agassiz, an accomplished zoologist, oceanographer and geologist, who made a fortune in Keweenaw copper and expended much of it on the Museum of Comparative Zoology and long geological and biological expeditions in the Pacific.

Agassiz, L. Agassiz, E. C. *Louis Agassiz, his Life and Correspondence.* 2 vols., Macmillan, 1885.

Founder of studies of glaciation, author of the greatest work on fossil fishes, founder of the Museum of Comparative Zoology at Cambridge.

———. *Louis Agassiz, sa Vie et sa Correspondence.* (transl. by A. Mayor.) Paris, 1887.

French edition, with slight additions, of the preceding.

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Parson Weemsish, fulsome, derivative, unimportant.

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Louis Agassiz seen through the eyes of his erratic but brilliant friend.

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A recent study, much less definitive than the preceding.

Andrews, R. C. Andrews, R. C. *Under a Lucky Star, a Lifetime of Adventure.* Viking Press, 1943.

Lively autobiography of the leader of the American Museum's expeditions to the Gobi Desert.

Bailey, L. W. Bailey, J. W. *Loring Woart Bailey.* J. & A. McMillan, St. John, N. B., 1925.

[2]Many important additions to the writer's original list were made by Dr. George W. White, of the University of Illinois; for which, sincere thanks are here given.

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Extremely readable anecdotes, mostly zoological, by the late Director of the Museum of Comparative Zoology.

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A fine study of a brilliant family. Alexandre was a geologist and mineralogist, director of the Sèvres porcelain factory and son of an eminent architect. Adolphe, his son, was famous as a botanist and paleobotanist.

Buckland, W. Gordon, Mrs. *The Life and Correspondence of William Buckland,* D.D., F.R.S. Appleton, 1894.

One of the best geological biographies, about one of the great figures in geology in the early years of the 19th Century,—Professor of Geology at Oxford, later Dean of Westminster.

Clarke, E. D. Otter W. *The Life and Remains of Edward Daniel Clarke.* 2 vols., London, 1825.

Professor of Mineralogy at Cambridge, famous traveller.

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Life of a lesser figure who worked valiantly in a formerly remote region.

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The pioneer paleontologist of the coastal plain Tertiaries.

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Definitive life of the driving figure of one of the greatest vertebrate paleontologists.

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Croll is noted for his contributions to the problem of the causes of continental glaciation.

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One of the best modern studies of Darwin.

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Very readable life of Australia's great field geologist and teacher.

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Discoverer of air-breathers in the Carboniferous of Nova Scotia, of *Eozoon,* professor of geology and principal of McGill University.

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Appealing and sympathetic account of the keen naturalist, discoverer of many new plants and fossil fishes, baker by trade, friend of Hugh Miller, Peach, and Geikie, but unknown to most of his contemporaries.

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Remarkably thorough study of one of the pioneer teachers of science in America, builder of Renssalaer Polytechnic Institute.

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Forbes, professor of natural philosophy at Edinburgh, later at St. Andrews, is famous for his studies of glaciers.

Forbes, E. Wilson, G., & A. Geikie. *Memoir of Edward Forbes.* 1860.
Edward Forbes was a pioneer in the study of animal ecology and geography.

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Geikie was an outstanding figure in British geology, long director of the Geological Survey of Great Britain.

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One of the best biographies of a scientist. Excellent study of the great Paleozoic paleontologist and lively account of the early days of geologic study of the classic ground in New York and adjoining areas. Much material on contemporary associates and geological activities.

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Horner was a Scottish geologist and merchant, the father-in-law of Charles Lyell.

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Huxley, celebrated biologist and forensic scientist, was the friend of Darwin and champion of the theory of evolution.

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The commerce of gem-stones, by an old and skilled dealer.

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Lamarck was the famous zoologist and paleontologist, proposer of an important pre-Darwinian evolutionary hypothesis.
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Very readable reminiscences of the student of Louis Agassiz and early professor of geology at the University of California.

Lesley, J. P. Ames, M. L. *Peter and Susan Lesley.* 2 vols., Knickerbocker Press, N. Y., 1909.

Linnaeus, C. Hagberg, K. *Carl Linné, "Le Roi des Fleurs."* (transl. from Swedish by Hammar and Metzger.) Paris, 1944.

Logan, W. E. Harrington, B. J. *Life of Sir William E. Logan.* London, 1883.
Good biography of a pioneer in Canadian geology.

Lyell, C. (Lyell, Mrs., ed.) *Life, Letters, and Journals of Sir Charles Lyell, Bart.* 2 vols., Murray, London, 1881.
Thoroughly readable selections from the letters and journals of the celebrated British geologist, scientific descendant of Hutton and expounder of uniformitarianism.
Bonney, T. G. *Charles Lyell and Modern Geology.* Macmillan, N. Y., 1895.
Based upon the "Life and Letters," but a more connected biography.

Mantell, G. Spokes, S. *Gideon Algernon Mantell.* London, 1927.

Marsh, O. C. Schuchert, C., & C. M. LeVene. *O. C. Marsh, Pioneer in Paleontology.* Yale Univ. Press, 1940.
An excellent companion volume to Osborn's "Cope." Marsh and Cope, the outstanding American vertebrate paleontologists, were bitter rivals.

Michell, J. Geikie, A. *Memoir of John Michell.* Cambridge Univ. Press, 1918.
Michell was "Fellow of Queen's College in Cambridge, 1749, Woodwardian Professor of Geology in the University, 1762."

Miller, H. Brown, T. N. *The Life and Times of Hugh Miller.* New York, 1859.
Poor.

Miller, H. *My Schools and Schoolmasters; or, the Story of my Education.* Boston, 1863.
The best extant account of the early life of Hugh Miller.

Bayne, P. *The Life and Letters of Hugh Miller.* 2 vols., London, 1871.
A long, prosy, dull, poorly-documented, and generally unsatisfactory biography.

Leask, W. K. *Hugh Miller.* Edinburgh & London (Famous Scots Series), 1896.
Excellent brief biography.

Mitchill, S. Hall, C. R. *A Scientist in the Early Republic, Samuel Latham Mitchill,* 1764–1831. Columbia Univ. Press, 1934.
A fair study of one of the more important early "all-round" scientists of America, friend and helper of many others.

Murchison, R. I. Geikie, A. *Life of Sir Roderick I. Murchison.* 2 vols., London, 1875.
Well-written, like all of Geikie's works. Murchison was one of the great figures of the formative years of geology and elaborator of the Silurian System.

Owen, D. D. Hendrickson, W. B. *David Dale Owen, Pioneer Geologist of the Middle West.* Indiana Historical Collections, vol. 27, 1943.
Owen was one of the most tireless and able of the early American geologists.

Owen, R. Owen, R. *The Life of Richard Owen.* 2 vols., Murray, London, 1894.
The letters and journals of the great English 19th Century anatomist and vertebrate paleontologist, celebrated for his deductions from fragmentary fossil bones.

Pengelly, W. Pengelly, H. *A Memoir of William Pengelly of Torquay, F.R.S., Geologist.* Murray, London, 1897.
Schoolmaster and keen "amateur" geologist.

Percival, J. G. Ward, J. H. *Life and Letters of James Gates Percival.* Ticknor and Fields Boston, 1866.
Poet and first state geologist of Connecticut.

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Powell was one of the founders of the United States Geological Survey, famous for his geological explorations in the West.

Prestwich, J. Prestwich. *Life and Letters of Sir Joseph Prestwich.* London & Edinburgh, 1899.

Pumpelly, R. Pumpelly, R. *My Reminiscences.* 2 vols., Henry Holt, 1918.
One of the most readable of scientific autobiographies, well-known for its real adventure and anecdotes.

Rafinesque, C. Rafinesque, C. R. *A Life of Travels.* Chronica Botanica, vol. 8, 1944. (1st ed., Phila., 1836.)
Fascinating self-portrait of one of the eccentrics of natural history, prodigious laborer among the hosts of new animals, plants, and fossils of America.

Fitzgerald, T. *Rafinesque, a Sketch of his Life, with Bibliography.* Des Moines, 1911.

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Excellent for its summaries of work of the period and portraits of geologists of the time.

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Saussure. Freshfield, D. W. *The Life of Horace Benedict de Saussure.* 2 vols., London, 1920.

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Say, who thought little of anything but his invertebrates, was a wistful and gentle figure in the roaring times when the midwest was the frontier.

Scott, W. B. Scott, W. B. *Some Memories of a Paleontologist.* Princeton Univ. Press, 1939.
Highly interesting, and in places equally diverting, recollections of one of our great vertebrate paleontologists.

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Exhaustive record of one of the great figures in British geology.

Shaler, N. S. Shaler, N. S. *The Autobiography of Nathaniel Southgate Shaler, with a supplementary Memoir by his Wife.* Houghton Mifflin, 1909.

Silliman, B. Fisher, G. P. *Life of Benjamin Silliman.* 2 vols., Scribner's, N. Y., 1866.
Life of the chemist, mineralogist, and founder of the *American Journal of Science* ("Silliman's Journal"), valuable for letters from other scientists of the early decades of the 19th Century.

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A fine account of one of the interesting figures at the British Museum (N. H.), famous bibliographer, indexer, and ferret of scarce scientific books.

Smith, W. Phillips, J. *Memoirs of William Smith, LL.D.* London, 1844.
Cox, L. R. *New Light on William Smith and his Work.* Proc. Yorks. Geol. Soc., vol. 25.

Sternberg, C. H. Sternberg, C. H. *The Life of a Fossil Hunter.* Henry Holt, N. Y., 1909.
Sternberg was the great professional fossil collector in the western United States.

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Werner, A. G. Frisch, S. G. *Lebensbeschreibung Abraham Gottlob Werner.* Leipzig, 1825.
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Wright, G. F. Wright, G. F. *Story of my life and work.* Bibliotheca Sacra, Oberlin, Ohio, 1916

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Selected series of letters, many hitherto unpublished, by Darwin, with extracts from his diary, during the voyage of the *Beagle.*

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The revealing journal of the discoverer of Iguanadon, especially interesting for its candid remarks on famous geologists of the early 1800's.

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One of the "musts" for every student of earth sciences.

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Agassiz, E. C. *A Journey to Brazil.* Boston & N. Y., 1895.

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Agassiz's first geological work in the United States.

Ansted, D. T. *Scenery, Science and Art.* London, 1854.
". . . extracts from the note-book of a geologist and mining engineer."

Campbell, J. F. *My Circular Notes.* 2 vols., Macmillan, London, 1876.
Letters from a leisurely round-the-world jaunt, with geological and other observations, by the author of "Frost and Fire." Interesting for the author's somewhat eccentric outlook.

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Account of a trip through the Rhine Valley region searching for materials for the cabinet of the Elector of the Palatinate; interesting observations on the columnar basalts which Collini discovered in the Rhine Gorge.

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Geological Travels in some parts of France, Switzerland and Germany. 2 vols., London, 1813.

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Adventures of a mining geologist in the gold-workings on the Caroni river in southeastern Venezuela.

Faujas de Saint Fond, B. *A Journey through England and Scotland to the Hebrides in* 1784 (transl. by A. Geikie). 2 vols., Glasgow, 1907.

Very readable account of a geological tour by a famous geologist of the 18th Century. Faujas was one of the first geologists to visit Fingal's Cave, Island of Staffa.

Forbes, J. D. *Travels in the Alps of Savoy and other parts of the Pennine Chain, etc.* Black, Edinburgh, 1843.

Classical reading for students of glaciation; early theory of glacial movement.

Lyell, C. *Travels in North America in the Years* 1841–42. 2 vols., New York, 1845.

Lyell came to America to give the Lowell lectures and took the opportunity to travel widely, studying not only the geology but also the manners and ways of the New World,—he found much that was good, some that was bad.

A Second Visit to the United States of North America. 2 vols., London, 1849.

Miller, H. *The Cruise of the Betsey; or, a Summer Ramble among the fossiliferous Deposits of the Hebrides.* (With: *Rambles of a Geologist; or, Ten Thousand Miles over the fossiliferous Deposits of Scotland.*) Boston, 1858.

Perhaps the most readable of Hugh Miller's works. If one does not long to visit the Hebrides and the Orkneys after reading this, he does not much love geology.

Pfitsenmayer, E. W. *Les Mammouths de Sibérie* (transl. from Russian by G. Montandon.) Payot, Paris, 1939.

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Pumpelly, R. *Across America and Asia. Notes of a five years' Journey around the World and of Residence in Arizona, Japan and China.* New York, 1870 (several eds.).

Pumpelly's famous trip around the world via an unusual route. Also re-counted in shorter form in his "Reminiscences" (see *Biographies*).

Rainier, P. *My vanished Africa.* Yale Univ. Press, 1940.

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Exciting account of a mining geologist's work re-opening some of the celebrated emerald mines of Colombia.

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Tavernier made several trips to the Orient in the 17th Century. Much valuable first-hand information on the mines of Golconda and famous precious stones now lost.

Willis, B. *Living Africa, a Geologist's Wanderings in the rift Valleys.* Whittlesey House, N. Y., 1930.

HISTORY OF GEOLOGY AND RELATED SCIENCES

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Not as broad as the title indicates. Good, brief account of the founders of geology, but concentrating almost wholly on American geologists after reaching the middle of the 19th Century.

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The best account of the development of geology during the 18th and 19th Centuries.

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Autobiographical review of de Margerie's great contributions to geology and geography, with many portraits, illustrations and facsimiles.

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Peattie, D. C. *Green Laurels, the Lives and Achievements of the great Naturalists.* Lit. Guild, 1936.

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Ramsay, A. C. *Passages in the History of Geology.* London, 1848, 1849.

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Brief but comprehensive.

Zittel, K. A. von. *Geschichte der Geologie und Paläontologie.* 1899.

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Brief, but still the best over-all history of geologic science. The German edition is longer.

MISCELLANEOUS

Benfield, E. *Purbeck Shop, a stonecutter's Story of Stone.* Cambridge Univ. Press, 1940.

Well-written story of the ancient craft of winning and working Purbeck stone in England.

Barbour, T. *A Naturalist's Scrapbook.* Harvard Univ. Press, 1946.

More anecdotes, posthumously published, by the late director of the Museum of Comparative Zoology.

Digby, Bassett. *The Mammoth, and Mammoth-Hunting in North-East Siberia.* Appleton, N. Y., 1926.

Dohm, B. *Stielauge der Urkrebs, eine Kronik aus Urzeiten unserer Erde.* Leipzig, 1933, 1942.

The somewhat anachronistic but amusing life and loves of Stalkeye the Trilobite (*Cyphaspis ceratophthalmus*).

Geikie, A. *Geological Studies at Home and Abroad.* Macmillan, 1882.

Scottish reminiscences. Maclehose, Glasgow, 1904.

Lee, J. E. *Note-Book of an amateur Geologist.* Longmans, Green, 1881.

Mostly reproductions of sketches of geological structures from the notebook of a widely-travelled "amateur."

Lees, E. *Pictures of nature in the Silurian region around the Malvern hills and vale of Severn.* London & Malvern, 1856.

Miller, Hugh. *The Old Red Sandstone; or, new Walks in an old Field.* Boston, 1860 (1st ed., 1841).

One of the few literary classics of geology. Hugh Miller here first made known to the layman the ichthyological wonders of the Old Red Sandstone.

Monnickendam, A. *Secrets of the Diamond.* Frederick Muller, London, 1941.

One of the best recent books on the fascinating history of the diamond trade.

Murdoch, A. *Boom Copper.* Macmillan, N. Y., 1943.

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Osborn, H. F. *Impressions of great Naturalists.* Scribners, 1924.

Sternberg, C. H. *Hunting Dinosaurs in the Bad Lands of the Red Deer River, Alberta, Canada.* San Diego, 1932.

Continuation of "Life of a Fossil-Hunter" (see *Biographies*).

Summers, R. A. *Conquerors of the River.* New York, 1939.

Semi-fictional account of Major Powell's famous expedition down the Grand Canyon of the Colorado.

Taine, J. (E. T. Bell). *Before the Dawn.* Williams & Wilkins, Baltimore, 1934.

Well-written, fictional account of a "time-reversal" machine which re-captured events of the geologic past.

Tait, S. W., Jr. *The Wildcatters.* Princeton Univ. Press, 1946.

Independent oil-hunting in America and the men who drilled wildcat wells.

Termier, P. *A la Gloire de la Terre; Souvenirs d'un Géologue.* Paris, 1924.

La Joie de connaitre; Suite de "A la Glorie de la Terre. Paris.

A NEW EYE-BANK

An affiliated "Eye-Bank" has been organized in New Orleans, La., which will have the cooperation of the Louisiana State University Medical School and the Tulane University Medical School and Hospital, it was announced recently at national headquarters of The Eye-Bank for Sight Restoration, Inc., 210 East 64th Street, New York City. Other affiliated Eye-Banks are functioning in Boston and Chicago.

The new Eye-Bank is located in the Hutchinson Memorial Building, New Orleans, and Mrs. Orville Ewing is serving as Executive Director. The officers are Charles E. Fenner, President; Dr. William B. Clark, First Vice-President; George L. Hardin, Second Vice-President; John F. Reilly, Treasurer; and John W. Sims, Secretary.

The Eye-Bank for Sight Restoration, Inc., in New York and its three affiliated Eye Banks collect and preserve healthy corneal tissue from human eyes for transplanting to blind persons who have lost their sight because of corneal defects, and this tissue is available to surgeons who are qualified to perform the corneal transplant operation. Two other objectives are the training of surgeons in the technique of the delicate corneal graft operation and the furtherance of research studies.

Dr. Clark, Vice-President of the New Orleans Eye Bank, who is a practicing ophthalmologist in that city, recently visited the national headquarters of The Eye-Bank for Sight Restoration, Inc., in New York to observe the methods used there as a model for the new affiliated Eye-Bank. Earlier, visits to New Orleans in connection with this project were made by Mrs. Aida de Acosta Breckinridge, executive director at national headquarters, and Dr. R. Townley Paton, New York ophthalmologist and Vice-President of the Eye-Bank there.

ADDITIONS TO THE REVISED CATALOGUE OF OHIO VASCULAR PLANTS. XIV[1]

CLYDE H. JONES,
The Ohio State University

1. *Ophioglossum vulgatum* L. Adder-tongue. Hocking Co. Floyd Bartley. Ringgold, Morgan Co. Clyde H. Jones.
3. *Botrychium neglectum* Wood. Wood's Grape-fern. Hocking Co. Floyd Bartley.
33. *Dryopteris noveboracensis* (L.) Gr. New York Shield-fern. Dundee, Tuscarawas Co. Charles Riley.
34. *Dryopteris thelypteris* (L.) Gr. Marsh Shield-fern. Augusta Twp., Carroll Co. Forest Buchanan.
37. *Dryopteris goldiana* (Hook.) Gr. Goldie's Shield-fern. Camp Muskingum, Carroll Co. Ethel Harper. Lake Co. Fred J. Tyler.
48. *Onoclea sensibilis* L. Sensitive-fern. Dundee, Tuscarawas Co. Charles Riley.
62. *Lycopodium selago* var. *patens* (Beauv.) Desv. Fir Club-moss. Carroll Co. Harold S. Vasbinder.
63. *Lycopodium lucidulum* Michx. Shining Club-moss. Orange Twp., Carroll Co. Forest Buchanan.
66. *Lycopodium obscurum* L. Tree Club-moss. Carroll Co. Harold S. Vasbinder.
73.1. *Pinus resinosa* Ait. Red Pine. Dundee, Tuscarawas Co. Introduced. Charles Riley.
81.1. *Echinodorus cordifolius* (L.) Griseb. Upright Bur-head. Pike Co. Floyd Bartley.
121. *Sparganium eurycarpum* Engelm. Broad-fruited Bur-reed. Fox Twp., Carroll Co. Forest Buchanan.
126. *Typha angustifolia* L. Narrow-leaf Cat-tail. Camp Muskingum, Carroll Co. Fay Given. Dundee, Tuscarawas Co. Charles Riley.
132. *Arisaema triphyllum* (L.) Torr. Jack-in-the-pulpit. Carroll Co. Harold S. Vasbinder.
141. *Scirpus cyperinus* (L.) Kunth. Wool-grass. Dundee, Tuscarawas Co. Charles Riley.
172. *Cyperus speciosus* Vahl. Michaux's Cyperus. Circleville Twp., Pickaway Co. Floyd Bartley.
174. *Cyperus inflexus* Muhl. Awned Cyperus. Union Twp., Ross Co. Floyd Bartley.
182. *Rynchospora cymosa* Ell. Grass-like Beak-rush. Oak Openings, Lucas Co. Floyd Bartley.
230. *Carex cristatella* Britt. Crested Sedge. Amsterdam, Carroll Co. Forest Buchanan.
262. *Carex meadii* Dew. Mead's Sedge. Cranberry Island, Buckeye Lake, Licking Co. Floyd Bartley and Leslie Pontius.
276. *Carex granularis* Muhl. Meadow Sedge. Fox Twp., Carroll Co. Forest Buchanan.
530. *Erythronium americanum* Ker. Yellow Dog-tooth Lily. Carroll Co. Harold S. Vasbinder.
531. *Erythronium albidum* Nutt. White Dog-tooth Lily. Carroll Co. Harold S. Vasbinder.
534. *Allium tricoccum* Ait. Wild Leek. Berne Twp., Fairfield Co. Charles Goslin.
561. *Trillium sessile* L. Sessile Trillium. Carroll Co. Harold S. Vasbinder.
564. *Uvularia perfoliata* L. Perfoliate Bellflower. Kilgore, Carroll Co. Forest Buchanan.
569. *Polygonatum comutatum* (R. & S.) Dietr. Smooth Solomon's-seal. Camp Muskingum, Carroll Co. Fay Given.
571. *Vagnera racemosa* (L.) Mor. Panicled False Solomon's-seal. Lake Co. Fred J. Tyler.
574. *Unifolium canadense* (Desv.) Greene. False Lily-of-the-valley. Carroll Co. Harold S. Vasbinder.

[1]Papers from the Department of Botany, The Ohio State University, No. 499.

584. *Smilax rotundifolia* L. Round-leaf Greenbriar. Camp Muskingum, Carroll Co. Roy McCormick and Laurabel Moony.
585. *Pontederia cordata* L. Pickerel-weed. Ashtabula Co. H. Crofoot and Fred J. Tyler.
593. *Juncus effusus* L. Common Rush. Dundee, Tuscarawas Co. Charles Riley.
606. *Juncus brachycarpus* Engelm. Short-fruited Rush. Wayne Twp., Pickaway Co. Floyd Bartley.
606.1. *Juncus polycephalus* Michx. Many-headed Rush. Oak Openings, Lucas Co. Floyd Bartley.
627. *Iris versicolor* L. Northern Blue-flag. Lake Co. Fred J. Tyler.
637. *Cypripedium parviflorum* Salisb. Yellow Lady's-slipper. Carroll Co. Harold S. Vasbinder.
645. *Lysias hookeriana* (Gr.) Rydb. Hooker's Orchis. Camp Muskingum, Carroll Co. Ethel Harper.
682. *Ranunculus micranthus* Nutt. Rock Crowfoot. Jefferson Twp., Ross Co. Floyd Bartley.
685. *Ranunculus pennsylvanicus* L.f. Bristly Buttercup. Wayne Twp., Pickaway Co. Floyd Bartley.
689. *Ranunculus septentrionalis* Poir. Swamp Buttercup. Carroll Co. Harold S. Vasbinder.
690. *Ranunculus hispidus* Mx. Hispid Buttercup. Carroll Co. Harold S. Vasbinder.
698.1. *Ficaria ficaria* (L.) Karst. Lesser Celandine. Van Wert Co. Arthur S. Brooks.
703. *Aquilegia canadensis* L. Wild Columbine. Carroll Co. Harold S. Vasbinder.
706. *Delphinium tricorne* Mx. Dwarf Larkspur. Steubenville, Jefferson Co. Forest Buchanan.
719. *Caltha palustris* L. Marsh Marigold. Carroll Co. Harold S. Vasbinder.
720. *Hydrastis canadensis* L. Golden-seal. Rushcreek Twp., Fairfield Co. C. H. Shaw and Charles R. Goslin.
724. *Syndesmon thalictroides* (L.) Hoffmg. Rue-anemone. Carroll Co. Harold S. Vasbinder.
725. *Isopyrum biternatum* Raf.) T. & G. False Rue-anemone. Crawford Co. Mary Hemmerly.
734. *Berberis thunbergii* DC. Japanese Barberry. Pleasant Twp., Fairfield Co. Escaped. Charles R. Goslin.
753. *Chelidonium majus* L. Celandine. Steubenville, Jefferson Co. Forest Buchanan.
755. *Bicuculla canadensis* (Goldie) Mills. Squirrel-corn. Yokum Hollow, Jefferson Co. Forest Buchanan.
779. *Lepidium campestre* (L.) R. Br. Field Peppergrass. Carroll Co. Harold S. Vasbinder.
786. *Thlaspi arvense* L. Field Penny-cress. Rock Run, Jackson Co. Floyd Bartley and Leslie Pontius.
802. *Barbarea barbarea* (L.) MacM. Yellow Winter-cress. Camp Muskingum, Carroll Co. Fay Given.
803. *Barbarea stricta* Andrz. Erect Winter-cress. Amsterdam, Carroll Co. Forest Buchanan.
809. *Arabis glabra* (L.) Bernh. Tower Mustard. Carroll Co. Harold S. Vasbinder.
817. *Cardamine bulbosa* (Screb.) B.S.P. Bulbous Bitter-cress. Carroll Co. Harold S. Vasbinder.
818. *Cardamine rotundifolia* Mx. Round-leaf Bitter-cress. Ross Twp., Jefferson Co. Forest Buchanan.
826. *Dentaria laciniata* Muhl. Cutleaf Toothwort. Carroll Co. Harold S. Vasbinder.
848. *Geranium maculatum* L. Wild Crane's-bill. Carroll Co. Harold S. Vasbinder.
851. *Geranium dissectum* L. Cut-leaf Crane's-bill. Jackson, Jackson Co. D. H. Harshberger via Glenn W. Blaydes.
872. *Impatience biflora* Walt. Spotted Touch-me-not. Camp Muskingum, Carroll Co. Fay Given.

874. *Impatience palada* Nutt. Pale Touch-me-not. Camp Muskingum, Carroll Co. Fay Given.
892. *Croton monanthogynus* Mx. Single-fruited Croton. Beaver Pond, Adams Co. Floyd Bartley.
897. *Tithymalus obtusatus* (Pursh.) Kl. and Garcke. Bluntleaf Spurge. Athens Co. Walter P. Porter and P. S. Wamsley.
928. *Hibiscus moscheutos* L. Swamp Rose-mallow. Buckeye Lake, Fairfield Co. Charles R. Goslin.
964. *Viola eriocarpa* Schw. Smooth Yellow Violet. Berne Twp., Fairfield Co. Charles R. and J. L. Goslin.
968. *Viola conspersa* Reich. American Dog Violet. Berne Twp., Fairfield Co. Charles R. Goslin.
970. *Viola rostrata* Pursh. Long-spurred Violet. Carroll Co. Harold S. Vasbinder.
973. *Viola odorata* L. Sweet Violet. Carroll Co. Harold S. Vasbinder.
975. *Viola blanda* Willd. Sweet White Violet. Carroll Co. Harold S. Vasbinder.
978. *Viola cucullata* Ait. Marsh Blue Violet. Jefferson Co. Forest Buchanan.
987. *Viola fimbriatula* Sm. Ovate-leaved Violet. Hocking Twp., Fairfield Co. Charles R. Goslin.
1002. *Alsine pubera* (Mx.) Britt. Great Chickweed. Yokum Hollow, Jefferson Co. Forest Buchanan.
1004. *Alsine graminea* (L.) Britt. Lesser Stitchwort. Camp Muskingum, Carroll Co. Fay Given.
1026. *Silene virginica* L. Fire Pink. Ross Twp., Jefferson Co. Forest Buchanan.
1032. *Saponaria officinalis* L. Bouncing-Bet. Camp Muskingum, Carroll Co. Fay Given.
1038. *Claytonia virginica* L. Spring-beauty. Carroll Co. Harold S. Vasbinder.
1068. *Chenopodium botrys* L. Feather-geranium. Fulton Co. Floyd Bartley.
1137.1. *Potentilla intermedia* L. Downy Cinquefoil. Pickaway Co. Floyd Bartley.
1144.1. *Duchesnea indica* (Andrew.) Focke. Indian Strawberry. Fairfield Co. Robert Goslin.
1177. *Rosa carolina* L. Swamp Rose. Camp Muskingum, Carroll Co. Fay Given.
1180. *Agrimonia rostellata* Wallr. Woodland Agrimonia. Camp Muskingum, Carroll Co. Fay Given.
1200.1. *Malus baccata* (L.) Borck. Siberian Crab-apple. Lake Co. Escaped. Fred J. Tyler.
1243. *Melilotus alba* Desv. White Sweet-clover. Camp Muskingum, Carroll Co. Fay Given.
1245. *Medicago sativa* L. Alfalfa. Camp Muskingum, Carroll Co. Fay Given.
1248. *Trifolium agrarium* L. Yellow Hop Clover. Berne Twp., Fairfield Co. Charles R. Goslin.
1256. *Trifolium hybridum* L. Alsike Clover. Camp Muskingum, Carroll Co. Fay Given.
1330. *Sedum ternatum* Mx. Wild Stonecrop. Geauga Co. H. C. Beardsley and Fred J. Tyler. Camp Muskingum, Carroll Co. Fay Given.
1340. *Chrysosplenium americanum* Schwein. Golden Saxifrage. Norton, Delaware Co. Trella Halderman. Crawford Co. Mary Hemmerly.
1374. *Ilex opaca* Ait. American Holly. Fairfield Co. Escaped. Charles R. and William Goslin.
1375. *Ilex verticillata* (L.) Gr. Winterberry. Carroll Co. Harold S. Vasbinder.
1391. *Schmaltzia crenata* (Mill.) Greene. Fragrant Sumac. Alexander Twp., Athens Co. Walter P. Porter.
1405. *Morus alba* L. White Mulberry. Berne Twp., Fairfield Co. Charles R. Goslin.
1406. *Toxylon pomiferum* Raf. Osage-orange. Lake Co. H. Crofoot and Fred J. Tyler.
1412. *Urtica gracilis* Ait. Slender Nettle. Camp Muskingum, Carroll Co. Fay Given.
1421. *Quercus montana* Willd. Rock Chestnut Oak. Ross Twp., Jefferson Co. Forest Buchanan.

1422. *Quercus bicolor* Willd. Swamp White Oak. Lake Co. H. Crofoot and Fred J. Tyler. Rushcreek Twp., Fairfield Co. Charles R. Goslin and P. J. Miller.
1431. *Quercus coccinea* Wang. Scarlet Oak. Springfield Twp., Jefferson Co. Forest Buchanan.
1433. *Quercus palustris* DuRoi. Pin Oak. Mechanicstown Marsh, Carroll Co. Forest Buchanan.
1456. *Populus alba* L. White Poplar. Kilgore, Carroll Co. Forest Buchanan.
1466. *Salix lucida* Muhl. Shining Willow. Augusta Twp., Carroll Co. Forest Buchanan.
1488. *Hydrangea arborescens* L. Wild Hydrangea. Camp Muskingum, Carroll Co. Fay Given.
1506. *Oenothera biennis* L. Common Evening-primrose. Dundee, Tuscarawas Co. Charles Riley.
1520. *Proserpinaca palustris* L. Mermaid-weed. Salt Creek Twp., Hocking Co. Floyd Bartley.
1532. *Asarum canadense* L. Canadian Wild-ginger. Camp Muskingum, Carroll Co. Fay Given.
1540. *Azalea lutea* L. Flame Azalea. Jefferson Twp., Ross Co. Floyd Bartley.
1543. *Epigeae repens* L. Trailing Arbutus. Carroll Co. Harold S. Vasbinder.
1548. *Gaultheria procumbens* L. Creeping Wintergreen. Carroll Co. Harold S. Vasbinder.
1550. *Pyrola americana* Sw. Roundleaf Wintergreen. Camp Muskingum, Carroll Co. Ethel Harper.
1553. *Chimaphila umbellata* L. Pipsissewa. Good Hope Twp., Hocking Co. Charles R. Goslin and Edward S. Thomas.
1554. *Chimaphila maculata* (L.) Pursh. Spotted Pipsissewa. Carroll Co. Harold S. Vasbinder.
1571. *Polemonium reptans* L. Greek Valerian. Carroll Co. Harold S. Vasbinder.
1582.1. *Phlox subulata* L. var. *australis* Wherry. Southern Ground Phlox. Springfield Twp., Jefferson Co. Forest Buchanan.
1584. *Ipomoea hederacea* Jacq. Ivy-leaf Morning-glory. Berne Twp., Fairfield Co. Charles R. Goslin.
1607. *Hydrophyllum virginianum* L. Virginia Waterleaf. Amsterdam, Carroll Co. Forest Buchanan.
1617. *Fraxinus pennsylvanica* Marsh. Red Ash. Ashtabula Co. H. Crofoot and Fred J. Tyler.
1628. *Gentiana andrewsii* Griseb. Closed Gentian. Carroll Co. Harold S. Vasbinder.
1689. *Penstemon hirsutus* (L.) Willd. Hairy Beard-tongue. Springfield Twp., Jefferson Co. Forest Buchanan.
1697. *Mimulus ringens* L. Violet Monkey-flower. Carroll Co. Harold S. Vasbinder.
1721. *Veronica americana* Schwein. American Speedwell. Ross Twp., Jefferson Co. Forest Buchanan.
1726. *Veronica serpyllifolia* L. Thyme-leaved Speedwell. Carroll Co. Harold S. Vasbinder.
1769. *Cynoglossum virginianum* L. Wild Comfrey. Camp Muskingum, Carroll Co. Fay Given.
1771. *Lithospermum latifolium* Mx. American Gromwell. Camp Muskingum, Carroll Co. Fay Given.
1779. *Myosotis arvensis* (L.) Hill. Field Forget-me-not. Pleasant Twp., Fairfield Co. Charles R. Goslin.
1801. *Scutellaria lateriflora* L. Mad-dog Skullcap. Camp Muskingum, Carroll Co. Fay Given.
1813. *Mentha piperita* L. Peppermint. Athens Co. Walter P. Porter and P. S. Wamsley.
1850. *Synandra hispidula* (Mx.) Britt. Synandra. Green Twp., Ross Co. Floyd Bartley.
1887. *Aralia racemosa* L. American Spikenard. Ross Twp., Jefferson Co. Forest Buchanan. Camp Muskingum, Carroll Co. Fay Given.

1889. *Aralia nudicaulis* L. Wild Sarsaparilla. Carroll Co. Forest Buchanan.
1891. *Panax trifolium* L. Dwarf Ginseng. Hocking Co. Floyd Bartley.
1894. *Hydrocotyl americana* L. American Marsh-pennywort. Green Twp., Ross Co. Floyd Bartley.
1908. *Thaspium barbinode* (Mx.) Nutt. Hairy-jointed Meadow-parsnip. Ross Twp., Jefferson Co. Forest Buchanan.
1914. *Heracleum lanatum* L. Cow Parsnip. Lee Twp., Carroll Co. Forest Buchanan.
1929. *Cicuta maculata* L. Spotted Water-hemlock. Camp Muskingum, Carroll Co. Fay Given.
1944. *Houstonia caerulea* L. Bluets. Carroll Co. Harold S. Vasbinder.
1946. *Houstonia ciliolata* Torr. Fringed Houstonia. Amsterdam, Carroll Co. Forest Buchanan.
1951. *Cephalanthus occidentalis* L. Buttonbush. Carroll Co. Harold S. Vasbinder.
1961. *Galium triflorum* Mx. Fragrant Bedstraw. Carroll Co. Harold S. Vasbinder.
1979. *Viburnum dentatum* L. Toothed Arrow-wood. Augusta Twp., Carroll Co. Forest Buchanan.
1981. *Viburnum lentago* L. Sheepberry. Amsterdam, Carroll Co. Forest Buchanan.
2002. *Valerianella locusta* (L.) Bettke. European Corn-salad. Hocking Co. Floyd Bartley.
2004. *Valerianella radiata* (L.) Dufr. Beaked Corn-salad. Amsterdam, Carroll Co. Forest Buchanan.
2014. *Specularia perfoliata* (L.) A. DC. Venus'-looking-glass. Ross Twp., Jefferson Co. Forest Buchanan.
2015. *Lobelia cardinalis* L. Cardinal Lobelia. Lake Co. Fred J. Tyler.
2112. *Antennaria plantaginifolia* (L.) Rich. Plantain-leaf Everlasting. Orange Twp., Carroll Co. Forest Buchanan.
2114. *Antennaria neodioica* Greene. Smaller Everlasting. Brush Creek Twp., Jefferson Co. Floyd B. Chapman.
2120. *Solidago bicolor* L. White Goldenrod. Springfield Twp., Jefferson Co. Forest Buchanan.
2122. *Solidago flexicaulis* L. Zig-zag Goldenrod. Springfield Twp., Jefferson Co. Forest Buchanan.
2147. *Aster divaricatus* L. White Wood Aster. Amsterdam, Carroll Co. Forest Buchanan.
2167. *Aster lateriflorus* (L.) Britt. Starved Aster. Springfield Twp., Jefferson Co. Forest Buchanan.
2170. *Aster ericoides* L. Dense-flowered Aster. Dundee, Tuscarawas Co. Charles Riley.
2179. *Erigeron philadelphicus* L. Philadelphia Fleabane. Amsterdam, Carroll Co. Forest Buchanan.
2231. *Senecio aureus* L. Golden Squaw-weed. Carroll Co. Harold S. Vasbinder.
2242. *Articum minus* Schk. Common Burdock. Camp Muskingum, Carroll Co. Fay Given.
2276. *Hieracium paniculatum* L. Panicled Hawkweed. Lake Co. Fred J. Tyler.

A STUDY OF THE BIOLOGY OF CHELONELLA SULCATA NEES (HYMENOPTERA: BRACONIDAE)

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INTRODUCTION

Chelonella sulcata Nees is a braconid belonging to the subfamily *Cheloninae*. It is a parasite of some of the most notorious cotton pests in Egypt (e.g., *Platyedra gossypiella* Saunders, *Ephestia kuehniella* Zeller and others). No important studies have been made on this species. This report represents a laboratory study of the biology of *Chelonella sulcata* Nees in Egypt.

The host used in this study was *Ephestia kuehniella* Zeller. *Chelonella sulcata* also was reared successfully in the laboratory from *Earias insulna* Bois., and *Platyedra gossypiella* Saunders.

MORPHOLOGY

Egg—(Pl. I. 1, 2). The length of the egg at oviposition equals 0.154 mm. and the width is 0.0567 mm. The egg of *C. sulcata*, immediately after deposition inside an *Ephestia* egg, is cylindrical, arcuate, or kidney-shaped. It is translucent, white in color, and has a smooth, glistening surface. As development proceeds, the egg becomes distended and the cephalic end broadens, but the length remains the same.

First-Stage Larva—(Pl. I. 3, 4). At eclosion the length is 0.36 mm., the head width 0.084 mm., the first thoracic segment width 0.062 mm., the first abdominal segment width 0.059 mm., and the length of the mandible 0.04 mm.

When 12 days old the total length is 0.084 mm., the head width 0.08 mm., the first thoracic segment width 0.24 mm., and the first abdominal width 0.23 mm.

The newly-hatched larva has a creamy-white body with eight well defined segments, the first of which is very large in proportion to the rest of the segments, and represents the head. This rather square head is followed by three thoracic and four distinct abdominal segments. The last abdominal segment is two times the length of any of the other segments and may be regarded as a division, since it probably represents several true, but as yet undifferentiated, segments. The anal segment is further lengthened into a blunt appendage.

The 12-day old larva differs considerably from the newly hatched larva. The head remains nearly the same size, while the body segments have enlarged. There are three thoracic and six abdominal segments. The first thoracic segment is relatively large and is at least 3.5 times as long as either of the following two segments. This segment probably represents the first thoracic segment since it does not further divide. The last abdominal segment is nearly five times as long as any of the other abdominal segments and bears on its dorsal surface a cap-like swelling which later continues to evaginate to form the anal vesicle.

Second-Stage Larva—(Pl. I. 5). Larval length near the end of this stage is 3.15 mm., greatest width 0.84 mm., head width 0.52 mm., length of mandible 0.10 mm.

[1]I wish to express my sincere gratitude to H. C. Efflatoon Bey, Professor of Entomology, Fouad Ist University, Egypt, to whom I am indebted for this problem and for his helpful suggestions and supervision. Appreciation is expressed to Dr. M. Kamal, Head of Insect Research Laboratory, Ministry of Agriculture, Egypt, for the use of the laboratory in which the present work was done; and to Dr. M. Hafez, Lecturer of Entomology, Fouad Ist University, Cairo, Egypt, for his many helpful suggestions and advice.

I also wish to thank Dr. Alvah Peterson, Professor of Entomology, The Ohio State University, for help in the preparation of the manuscript.

The larva is now crescent-shaped, with a spherical body destitute of spines. It possesses a rounded head followed by twelve segments, i.e., 3 thoracic and 9 abdominal, not counting the anal vesicle, which is well developed in this stage. The larva is more opaque and has a creamy color. The old skin or exuvium of the first-stage larva is attached to the posterior end of the last abdominal segment.

Third- (*Last-*) *Stage Larva*—(Pl. I. 6). The length after external feeding period is completed is 6.5 mm., the width 1.9 mm., mandible length 0.147 mm., and the average length of the large dorsal spines 0.098 mm.

Upon issuance from the host, the larva is cylindrical and possesses 14 body segments. The body is creamy in color and the skin is thickly covered with minute blunt spines. Dorsally on each of the abdominal segments 1–9, inclusive, are located a few long and dark-brown chitinized spines. These spines occur on each of the nine segments in two short, transverse rows, one on each side of the dorsomeson. Those spines on the dorsomeson have the greatest length.

There are rather large lateral lobes on the first 9 abdominal segments produced by the arrangement of the muscles in that part of the body. Eight spiracles are located on the lateral aspects and near the anterior margin of the second thoracic and first 7 abdominal segments.

After completing its external feeding, the larva is plump, with the lateral lobes distinctly swollen. The color varies from cream to light brown.

Pupa—(Pl. I. 7). The length of the pupa is 4.3 mm., and its width 1.6 mm.

The pupa is of the exarate type, with the legs, wings and antennae free. During this stage it exhibits no movement. For the first four or five days, about half of the pupal period, it is pale yellow in color. The color gradually darkens during the later half of the pupal stage.

Adult—(Pl. II. 8). The length of the imago is 4.1 mm., and its breadth with the wings extended is 6.7 mm.

It is black in color, with smoky wings. The antennae are filiform with sixteen segments in the female and twenty-three in the male. The abdomen is covered dorsally and laterally by a single hard, convex sclerite or carapace, which is creamy-white in its anterior half. At the extreme base of the carapace is a small, semi-circular black area. The carapace of the male has an apical oval foramen with a breadth of from 1.5 to 2 times the length, where the length equals the perpendicular height on the apex of the carapace. The body is punctured all over by irregular polygonal areas. Each area gives rise to a hair near its center.

BIOLOGY

Oviposition—If the eggs of *Ephestia* are exposed to the females of *Chelonella* for a period of 24 hours, eggs of the parasite will be deposited within the host eggs. The number of *Chelonella* eggs deposited within an egg of *Ephestia* varies according to the number of the host eggs exposed. When the *Ephestia* eggs are few in number, the number of *Chelonella* eggs deposited per host egg is large.

The *Chelonella* eggs hatch within the egg of *Ephestia*. The hatching period varies with the temperature. It takes 3 to 5 days at 20° C. and 2 days at 28° C. The hatching period of the host eggs (*Ephestia*) takes seven days at 20° C. and four days at 28° C.

Apparently all of the *Chelonella* eggs deposited within the host egg hatch. In some cases as many as nine larvae were dissected out of a single *Ephestia* egg, but only one survives (see section on larval development) and completes its development.

A pre-oviposition period or mating are not essential to egg-laying. The female *Chelonella*, upon emergence from the cocoon, has within her ovaries a number of well developed eggs, which she will deposit at once, if provided with host eggs.

A *Chelonella* female moving about in a cage containing a card of *Ephestia* eggs, appears to note the presence of host eggs when she is about one to two cm. from

them. She waves her antennae rapidly, rubs her body and hind legs with her wings, and approaches the eggs. Immediately the antennae are lowered with the tips flattened against the card containing the eggs. The antennae are pushed forward until they encounter the eggs and then the tips are brushed over the surface of one of the eggs. The female draws her body directly forward a short distance and at the same time unsheaths her short ovipositor and inserts it vertically into the egg. During oviposition the female stands motionless over the host egg with her antennae extended straight out before her and bent slightly downwards; the abdomen is at a 90° angle with the rest of the body and the wings on a straight line with the thorax and the head. The first movement following the deposition of the eggs are, a withdrawal of the ovipositor, straightening of the abdomen and a slight vibration of the antennae. The female then turns around, searching for another egg, and the process is repeated. This procedure is repeated until every egg on the card is parasitized or until the female has deposited all of the mature eggs contained in her ovaries, as verified by dissection.

Pierce and Holloway (1912), describing the parasitizing of eggs of *Laphygma frugiperda* (A. & S.) by *Chelonus texanus* Cress., mentioned the moving forward of the abdomen just prior to oviposition, and this was later confirmed by Luginbill (1928). A similar behavior was observed by Vance (1932) during the oviposition of *Chelonus annulipes* Wesm. in the eggs of *Pyrausta nubilalis* (Hbn.).

It takes from 10 to 25 seconds for a regularly ovipositing *C. sulcata* female to lay a number of eggs inside that of *Ephestia*. However, the process often takes several minutes. For example, one *Chelonella* female on her first day of oviposition, was observed to deposit 98 eggs inside 9 host eggs, spending an average of one minute and fifteen seconds at each oviposition. A maximum of three minutes and thirty seconds was required for one deposition and a minimum of ten seconds for another.

The age of the host eggs does not influence the choice of the female in her selection, nor does host egg age influence the development of the parasite.

It has been observed that there is a direct relationship between the rate of oviposition of *Chelonella* and the amount of food consumed. It has been found that when a female *Chelonella* is deprived of food, which consists of honey placed as small drops in a row on each side of the midrib of a *Nerium* leaf, she does not oviposit the normal number of eggs. Whereas when the same female was supplied with ample food, the number of eggs oviposited was much greater.

The incubation of the eggs of *Chelonella sulcata* varies with the temperature, the higher the temperature, the shorter the incubation period and vice-versa. One day is the shortest incubation period between March and the end of November. This minimum period occurred in July, whereas the longest incubation period (5 days) occurred during the latter part of March and the beginning of April. Also, the average incubation period is four days during March, three days during

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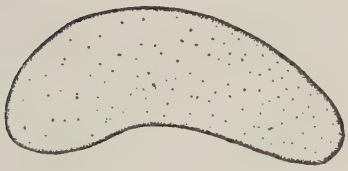
EXPLANATION OF PLATE I

FIG. 1. Chelonella egg just after deposition inside host egg. Length, 0.154 mm.
FIG. 2. Chelonella egg just before hatching. Length, 0.154 mm.
FIG. 3. Dorsal view of first-stage larva just after hatching. AS, anal segment; AP, appendage; H, head; PT, prothorax. Length, 0.26 mm.
FIG. 4. Ventral view of 12-day old first-stage larva. AV, anal vesicle; H, head; LP, labial process; Mn mandible; PT, prothorax. Length, 0.8 mm.
FIG. 5. Lateral view of second-stage larva. AV, anal vesicle; H, head; LM, exuvium of first-stage larval moult. Length, 3.15 mm.
FIG. 6. Lateral view of last-stage larva. A, anus; FS, first abdominal spiracle; H, head; LL, lateral lobe; SS, seventh abdominal spiracle; TS, thoracic spiracle. Length, 6.5 mm.
FIG. 7. Lateral view of late pupal stage. Length, 4.3 mm.
FIG. 8. Dorsal view of adult *Chelonella sulcata*. Length, 4.2 mm. Width of wings stretched, 6.75 mm.



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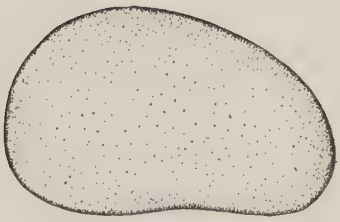

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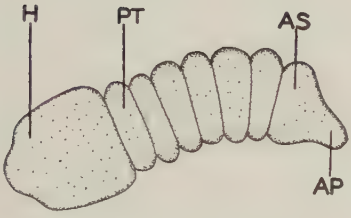

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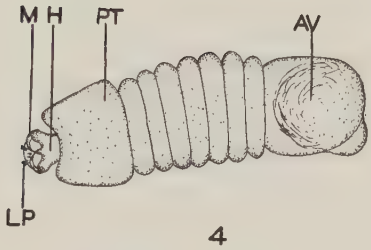

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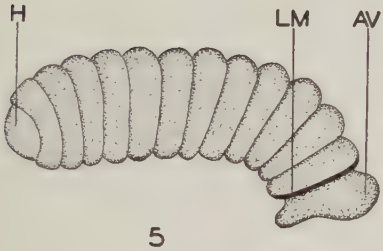

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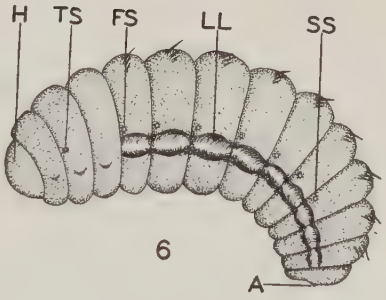

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April, three days during May, two days during June, July, August, September and October, and three days during November.

Effect of Temperature on Oviposition—The temperature at which the females are kept influences oviposition. By working out the minimum and maximum temperatures at which no oviposition took place, it has been found that a temperature of 15° C. is the minimum and a temperature of 40° C. is the maximum. The number of eggs oviposited increased as the temperature rose. It was noted that the females kept at a temperature of 35° C. had died nine days earlier than those kept at 26° C. This indicated that high temperature shortens the life of the insect and also accelerates the rate of oviposition.

Larval Development—The larva of *Chelonella sulcata* is strictly an endoparasite which spends practically all of its life free within the body cavity of the host larva. A general idea of the advancement of the larval development is obtained from numerous host larva dissections coupled with a study of the body size, molted skin, form of the mandibles and widths of the head capsules.

The parasite passes through three distinct larval instars, moulting twice within the host, while the third moult takes place outside the host, within the newly-spun cocoon. The cast skins of the first and second moults are pushed back towards the posterior end of the larva, where they remain attached in the form of a thin dark ribbon at the base of the anal vesicle, especially in the case of the second-stage larva. In both larvae, they remain attached for a short time before they are entirely shed. The third moult takes place within the newly-spun parasite cocoon and can be easily seen at the posterior end of the white silvery cocoon.

The length of the larval stages varies considerably with the temperature. Under constant temperature of 27° C. dissection of about 90 *Ephestia* larvae of different ages containing *Chelonella* parasites showed the length of the larval stages to be approximately as follows: The first stage lasts 16 days, second stage 4 days, last stage (internal) one day and last stage (external) two days, or a total of 23 days. Considerable individual variation occurs in the length of the stages, especially among the first stage larvae for the six generations. Table I gives the average lengths of the three larval stages during the six generations per year.

The *Chelonella* larva of the sixth generation spends nearly three months of the year as a late first-stage larva within the hibernating host larva.

About 200 parasitized *Ephestia* larvae were placed at a constant temperature of 27° C. Nineteen *Chelonella* larvae emerged from these host larvae, averaging 25 days, counting from the time the parasite eggs were deposited until the issuance of the *Chelonella* larvae from the host. The pupation of 40 unparasitized host larvae subjected to the same temperature and reared at the same time, counting from the time the other host eggs were exposed to oviposition by *Chelonella* until the pupae were formed, required an average of 31.3 days. The *Chelonella* larvae had left their host larvae on an average of 6.3 days earlier than the latter normally pupated.

As has been noted before, *Chelonella* oviposits within the eggs of *Ephestia* and all of the eggs hatch within the host egg. As many as fourteen parasite eggs have been dissected from one *Ephestia* egg. When the host eggs hatch, not more than two parasite larvae can be found within the host. This condition does not last long, for within 24 hours after the *Ephestia* has hatched, only one of the *Chelonella* larvae survives. Great numbers of dissections have never shown more than one second-stage larva per host. Also in rearing many hundreds of individuals, not more than one mature parasitic larva has emerged from a single parasitized host.

Issuance of Last-Stage Larva and its External Feeding—Prior to issuance of the last stage larva of *Chelonella* from its host, the parasitized *Ephestia* larva spins a very loose, oval coooon which is strengthened in part by food particles of coarse

crushed maize (corn meal). About one-third of the cocoon is free of maize particles and remains a thin silky sheet through which the larva can be seen. The color of *Ephestia* larvae changes from yellowish-brown to creamy-white. It becomes plump and develops an appearance similar to that of an undersized prepupa. On dissection of such a parasitized larva, the third stage larva of *Chelonella* is seen lying with its ventral surface against the dorsal wall of the host larva. Also its head is directed cephalad to the *Ephestia* larva. After transforming into the last stage, the parasite larva remains from half to one day within the host larva. By means of its powerful dentated mandibles, it eats its way out through an incision in the dorsal integument of the host.

After making an incision in the dorsum of the host larva with its mandibles, the parasite larva protrudes its head from the opening, followed by the rest of the body. The head and body segments are directed towards the posterior end of the host larva. When all the abdominal segments are withdrawn from the host, the *Chelonella* larva begins its external feeding at some point on the dorsal surface

TABLE I

AVERAGE LENGTH OF THE THREE LARVAL INSTARS OF *Chelonella sulcata* DURING THE SIX GENERATIONS ANNUALLY

Generation Number	Average Temp. During Generation	Maximum Temp. During Generation	Minimum Temp. During Generation	Average Length of Time of			Average Length of Larval Stages	Maximum Duration of Larval Stages	Minimum Duration of Larval Stages
				First Stage Larva	Second Stage Larva	Third Stage Larva			
	In degrees centigrade	In degrees centigrade	In degrees centigrade	Days	Days	Days	Days	Days	Days
First	21.47°	27.0°	17.0°	31	5	3	39	45	38
Second	26.2°	29.5°	23.5°	28	5	3	36	40	35
Third	28.0°	29.0°	26.5°	18	4	3	25	25	24
Fourth	26.7°	29.0°	26.0°	16	4	2	22	24	22
Fifth	23.9°	28.0°	21.0°	44	5	3	52	64	36
Sixth	22.4°	23.0°	21.0°	83	5	3	91	96	88

near the caudal end of the host larva. Then it curls its head to the right or left, followed by the rest of the body segments, and moves slowly towards the cephalic end of the host larva. During its movement, it makes other incisions in the body and continues its feeding upon the internal organs of the host larva.

After completing its external feeding, which takes from 24 to 48 hours, nothing remains of the host larva except the empty skin and the chitinous exoskeleton of the head. The *Chelonella* larva becomes more rounded and when dissected, the peritrophic membrane is found full of pieces of the host trachea, fat, alimentary canal and other parts of the internal organs of the host larva.

Cocoon Formation—A few days before the last stage larva of *Chelonella* issues from the body of the host larva, the host spins a thinly constructed cocoon which some writers call the "death-cell." After the parasite larva finishes its external feeding, it rests quietly for about 24 hours. It then starts spinning its cocoon within this so-called death-cell of the host. The construction of the cocoon takes from a half to one day.

The cocoon is constructed of silk white threads, coming out of the external opening of the common silk duct situated on the upper border of the labium of the last-stage larva. The larva, during cocoon construction, moves its head upwards, downwards, forwards and backwards. The silk threads which emerge in a semi-liquid state are gradually woven into a silver-white papery cocoon.

This cocoon is loosely spun exteriorly, but more tightly woven towards the interior, and is attached by the outer threads to the "death-cell." The head capsule and dry skin of the host larva are found outside the cephalic region of the parasite cocoon between the latter and the "death-cell."

A number of experiments were made to determine the effect of external factors on the parasite larva during cocoon formation and pupation. If after its external feeding, the *Chelonella* larva is transferred from its place to a glass tube containing fresh, finely crushed maize, the larva being deprived of its host cell, does not spin its normal cocoon. Much silk comes out of the silk glands, and is woven around the larval head in an irregular fashion which produces a cap over the head. The larva does not live long, usually dying two days before it would normally pupate. In general, it can be said that any disturbance of the parasite larva when it is ready to spin a cocoon, upsets cocoon formation and produces an abnormal distribution of silk which in the end results in death.

Pupal Development—The cocoon of the parasite is spun in about 24 hours and, when finished, the larva ceases movement and rests quietly while transformation begins. One may observe with difficulty through the semi-transparent cocoon the changes the larva undergoes. The thorax and the head become distended and a slight constriction appears between the thorax and the abdomen. The eyes become pigmented and visible and the appendages also appear. This is the prepupal stage common to Hymenopterous parasites. Shortly thereafter, the meconium of the larva is expelled. The prepupal stage does not last more than a few hours and it is difficult to observe. The appendages of the pupa become more and more visible underneath the prepupal skin. The prepupal skin then splits from six to twelve hours after the casting of the larval meconium, beginning at the top of the head and slipping slowly posteriorly, revealing a pale yellow pupa with its perfect appendages. The casting of the larval meconium can be taken for practical purposes to indicate the beginning of the pupal stage. The emergence of adult *Chelonella* from the cocoon may be considered as the end of the pupal period, though the imago may remain within the cocoon a short time after it has been completely formed.

The *sulcata* pupa lies in the posterior two-thirds of the cocoon with its abdominal tip more or less submerged in the larval meconium which is a grayish-black semi-liquid substance located within the inner wall of the cocoon at its caudal extremity.

During development, the color changes of the pupa are distinct. During the first four or five days, or about half of the pupal period, it is pale yellow in color. During the latter half of the stage, the body darkens gradually. The eyes and ocelli in the early stages are light brown and gradually darken to brown. The antennae, head, thorax and the dorsum of the posterior half of the abdomen change from pale yellow to pale brown, to brown, and then become black. The legs also darken and the wings become smoky, with the stigma and wing veins dark brown. The somewhat protruded ventral part of the abdomen remains pale yellow in color in its anterior half, and the posterior half becomes dark brown. The ovipositor becomes brown-colored.

The effect of temperature upon pupal development is quite evident. A temperature of 8° C. serves to retard pupal development, and too long exposure to such low temperature apparently results in high mortality. An experiment was made to determine the exact length of time that *Chelonella* pupae might be subjected to a low retarding temperature and still obtain satisfactory emergence of adults after the cocoons were again exposed to higher temperatures. Fifty cocoons, containing prepupae or early pupae, were placed in a refrigerator at a constant temperature of 8° C. After 25, 30, 35, 40, and 50 days, ten cocoons were taken out, examined, and placed at a temperature of 27° C. The number

of adults that emerged were counted. It is evident from this experiment that most of the pupae remain in an early state of development during their exposure to the low retarding temperature. It appears that 40 days is the maximum length of time that *Chelonella* pupae may be subjected to 8° C. and still emerge after their cocoons were exposed to the higher temperature of 27° C.

Emergence of Adult—Inside the cocoon the black-colored adult is indistinctly visible through the semi-transparent silvery cocoon wall. A cocoon just prior to adult emergence was observed under a binocular microscope. The adult *Chelonella* is oriented with its head a few mm. from the anterior end of the cocoon. When about to emerge, frequent movements of the legs, antennae and wings take place, followed by a pushing forward of the whole body of the insect until the head comes close to the cocoon wall. Then the mandibles of the adult insect begin to tear away the silk threads at the tip of the cocoon. This cutting process continues until a hole is made wide enough for the emergence of the body. The insect then shoves its way gradually through this opening. The head protrudes first, followed by the thorax and then the abdomen. The newly emerged adult is quite dry, vivid, and moves actively about inside the glass vial. The cast meconium of the last larval stage and pupal skin may be found at the opposite end of the cocoon. Adults may emerge anytime during the day or night.

Feeding—Various materials have been tested as food for the adults, including sugar lumps, honey, and sugar solutions in soft cotton. Honey proved to be the most successful food for *Chelonella*.

Parthenogenesis and Unisexual Reproduction—It has been found that fertilization in female *Chelonella sulcata* is neither a stimulus nor an absolute condition for oviposition. Unmated females oviposit readily and all their progeny are females. In all of the breeding tests no males were seen. Generation after generation always produced females. This indicates a state of unisexual reproduction in which females always produce females without the intervention of males. This phenomenon occurs frequently among the parasitic *Hymenoptera*. Unisexual reproduction is normal in a number of species of *Braconidae*, among which may be mentioned *Apanteles thompsoni* Lyle, *Roges unicolor* Wesm., *Meteorus japonicus* Ashm., and *Microctonus brevicollis* Hal. Not a single male of *Apanteles thompsoni* Lyle has ever been secured in the large-scale rearings that were made by Vance (1931). Under laboratory conditions, all rearings produced females only. Green cotton bolls collected from the field of the Giza experiment station were brought into the insectary until the parasites emerged. Of 100 *Chelonella sulcata* adults collected, two were males and the remainder females. The two males were placed with two females in glass vials and were subjected to artificial strong light for six hours at 27° C. to encourage mating. Copulation was seen to take place and *Ephestia* eggs were then exposed to these mated females. They oviposited normally in these eggs and the host eggs were reared until the adults of *Chelonella* emerged and all were females. In other words, we have an example of a class of insects in which females are produced almost constantly and the opposite sex is rarely encountered. This type of reproduction among parasitic *Hymenoptera* is known as "thelytoky."

Adult Longevity—Chelonella sulcata adults are hardy insects. Forty-eight freshly emerged adults confined in separate glass vials covered with muslin, were subjected to various temperatures and food conditions and observed daily. The data obtained from these observations are shown in Table II. Temperatures 8° C., 15° C. and 30° C. were electrically controlled and were practically constant. The room temperature was that of the laboratory, which ranged between 20° C. and 28° C. while the experiments were in progress. The food consists of honey. Water was provided daily by a water-soaked cotton wick placed in the bottom of the glass vials. The results show that *no* food or water produced the shortest

longevity (2 to 5 days), while tests with food and water provided optimum longevity (10 to 33 days). Tests with food alone, 6 to 15 days, and with water alone, 4 to 8 days, gave intermediate results.

The noticeable effect of temperature was a shortening of the life of the individuals kept at 8° C. and supplied with both food and water. Laboratory temperatures which fluctuated around 26° C. at the time of the experiment were very favorable to longevity, provided the adults were given both food and water.

Effect of Parasite on Host—Externally, there appears to be no distinguishable difference between parasitized and non-parasitized host larvae up to and including the third instar. After the third instar, the non-parasitized larvae grow more rapidly and are larger than the parasitized individuals. It has been found that the average length and breadth of non-parasitized larvae is 13.5 and 2.5 mm., and that of parasitized larvae is 6.45 and 1.35 mm. This means that the parasitized larva is smaller in size than the non-parasitized by an average of 7.05 to 1.15 mm.

TABLE II

Effect of Various Temperatures and Food Conditions on the Longevity of Adult *Chelonella sulcata*

Temperature	With Food and Water		With Food Alone		With Water Alone		With No Food or Water	
	Individuals	Average	Individuals	Average	Individuals	Average	Individuals	Average
	Days	Days	Days	Days	Days	Days	Days	Days
8° C.	10, 12, 18	13.3	9, 8, 6	7.6	5, 6, 4	5	4, 5, 2	3.6
15° C.	20, 25, 19	21.3	8, 12, 11	10.3	6, 8, 5	6.3	3, 4, 3	3.3
30° C.	28, 26, 22	25.3	10, 11, 9	10	7, 5, 8	6.6	2, 3, 4	3
Room	33, 31, 29	31	12, 15, 14	13.6	8, 6, 7	7	3, 2, 5	3.3

*Each of these numbers represents the longevity of one individual confined in a separate glass vial.

The parasite not only effects the size of the host, but also retards its development. In the summer generations, which extend from April to the end of November, the non-parasitized larvae continue their development into the sixth or last larval instar and pupate normally. Those larvae of the same generations, which contain *Chelonella* larvae are so retarded in growth that the parasites issue before the *Ephestia* larvae have entered the last instar. In the winter generation, which lasts from the end of November to the middle of March, both the non-parasitized and parasitized larvae hibernate. The non-parasitized host larvae hibernate as the last instar, and the parasitized individuals hibernate as fourth-instar larvae and are smaller in size than the normal host larvae. During this generation, the parasitized host larvae can be easily separated from the non-parasitized by their size.

The color of the parasitized larvae is pale yellow, and differs from that of the non-parasitized individuals, which are buff-colored.

The parasitized host larva during its inactive stage is enclosed and lies motionless in a light woven cocoon. The third or last stage larva of the parasite finds its way out of the host larva and begins its external feeding, eventually leaving only the shrunken cuticle and chitinized head-parts of the host.

Not a single host larva lived after the emergence of the *Chelonella* last-stage larva. This conclusion was also reached by Vance (1931), in the case of *Apanteles thompsoni* Lyle, parasitic on *Pyrausta nubilalis* (Hbn.) where he said "death is the fate of any larva of *Pyrausta nubilalis* from which *Apanteles* larvae have issued, and in no known instance has pupation of the host followed."

Life History and Number of Generations—The life history of *Chelonella sulcata* was taken from records made under laboratory conditions. *Ephestia kuehniella* was the host used in the laboratory for rearing the parasites. It was found that the life-cycle of *Chelonella* is dependent to a considerable extent upon the rate of development of the host. The number of generations of the parasite corresponds to that of its host. The experiments made during 1943 and 1944 showed that the *Chelonella* female began oviposition directly after emergence, provided it was supplied with eggs of *Ephestia*. If we take the middle of March

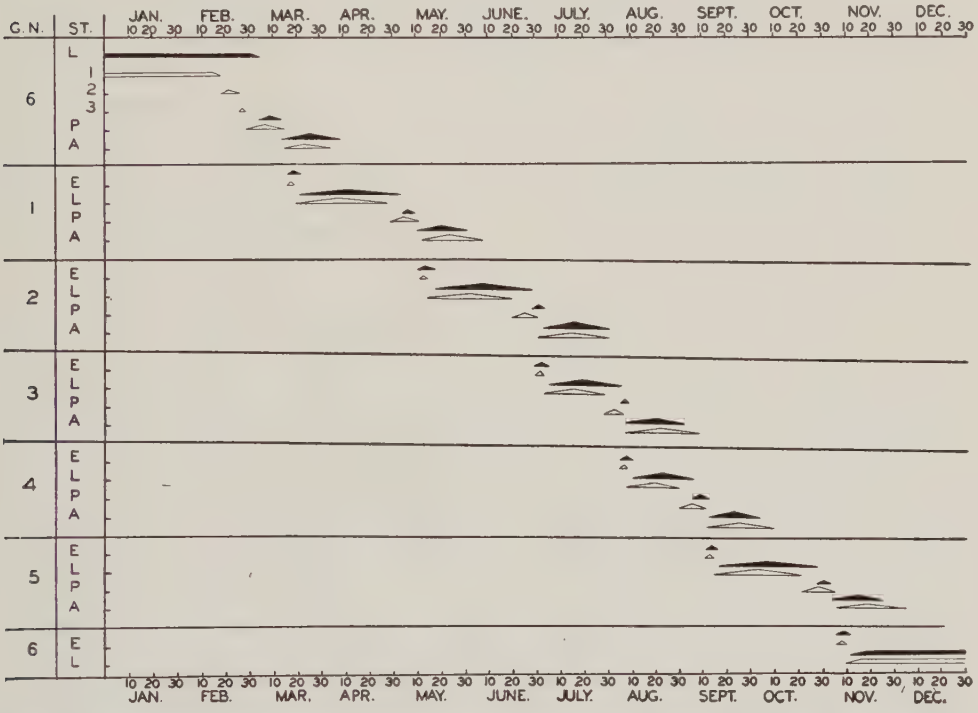

FIG. 1. The duration of stages of both *Chelonella sulcata* Nees (parasite); *Ephestia kueheniella* Z. (host) during the six generations per year and the longevity of the adult in each generation. Host in dark areas.

as a point when the adult parasite comes out from the hibernating larva, and December 5th as the date the parasitic females cease ovipositing, we obtain as many as six generations.

The relationship between the life history of the parasite *Chelonella* and its host *Ephestia* is clearly demonstrated in Fig. 1, made from data of daily observations over a two-year period.

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SHELLMOUND INDICATING TRACE OF ANCIENT POPULATION FOUND IN SOUTHERN MEXICO

A large shellmound, or "kitchen midden," which may prove to be the first trace of a pre-pottery, pre-agricultural population, has been discovered in southern Mexico by an archeological expedition of the National Geographic Society and the Smithsonian Institution, in cooperation with the Instituto Nacional de Antropologia y Historia of Mexico.

The shellmound was found in the state of Chiapas, in the area of advanced Indian civilizations of southern Mexico and Central America. It is situated on the Pacific coast, bordering a lagoon surrounded by mangrove swamps.

The huge mass contains clam shells, mixed with earth, charcoal and ash, and various objects of human manufacture, piled in a heap about 350 feet long and 250 feet wide and more than 10 feet high.

A test trench dug in the mound produced a few fragments of weathered, rather crude pottery from the uppermost levels. In the lower portion no pottery was found. Only obsidian knives and pieces of worked and shaped animal bones were uncovered to represent the manufactures of the ancient inhabitants.

The scientific importance of the find lies in the fact that the lower levels appear to represent a culture which existed in southern Mexico before the invention of agriculture and pottery-making—that is prior to the archaic beginnings of the high civilizations of the Maya, the Olmec, and the Zapotecs.

The existence of such an ancient hunting and shell-gathering economy has been speculated on by archaeologists who have worked in Middle America, but this is the first discovery that can be attributed to such a culture. Thus, the shellmound may contain the earliest cultural remains yet found in southern Mexico.

The survey party was led by Dr. Philip Drucker of the Smithsonian Institution. The trip was designed to investigate the archeological resources of the coastal plain of Chiapas, which at one time formed a corridor for the exchange and spread of culture between the populations of Central America and those of southern and central Mexico. Little archeological research had previously been done in the region.

Besides the shellmound, numerous sites were found, some of which relate to early phases in the development of Maya culture, and others to later times, not long before the Spanish conquest of the region.

Dr. Drucker previously had served as an assistant to Dr. Matthew W. Stirling of the Smithsonian Institution on a series of National Geographic Society-Smithsonian expeditions to Veracruz State, across the southern Mexican isthmus from Chiapas.

Those expeditions, conducted for eight seasons, resulted in the acquisition of considerable information about the pre-Columbian people of the region. In 1939 the explorers located a stone bearing in Mayan symbols the earliest recorded date found in the Western Hemisphere—November 4, 291 B. C. Among a large number of sculptures uncovered by the expeditions were colossal stone heads. The two largest, discovered in 1946, stand about 10 feet high and are estimated to weigh more than 20 tons each.

ANNUAL REPORT OF THE OHIO ACADEMY OF SCIENCE
1947

THE OHIO ACADEMY OF SCIENCE

Organized 1891 Incorporated 1892
Affiliated with the American Association for the Advancement of Science

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E. *Psychology:* JAMES VAUGHN
F. *Physics and Astronomy:* R. L. EDWARDS
G. *Geography:* F. J. WRIGHT
H. *Chemistry:* W. M. BURGESS
I. *Mathematics:* R. A. MANCHESTER
J. *Junior Academy:* (Not elected)
K. *Anthropology:* J. W. BENNETT

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RUSH ELLIOTT

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C. L. DOW, term expires....1948
E. W. E. SCHEAR, term expires....1948
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C. E. TAFT, term expires....1949
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R. W. FRANKS, term expires....1950
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Committee on Nominations for 1947–1948
THE VICE-PRESIDENTS OF 1946–1947—W. C. BEAVER, *Chairman*

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F. *Physics and Astronomy:* W. R. PYLE
G. *Geography:* F. A. CARLSON
H. *Chemistry:* W. A. EVERHART
I. *Mathematics:* (Not elected)
J. *Junior Academy:* (Not elected)
K. *Anthropology:* J. N. SPUHLER

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1. On the Joint Administrative Board of the Ohio Journal of Science:
   A. C. Anderson, term expires.....1949
   R. A. Heffner, term expires.....1951
2. On the Council of the A. A. A. S.: Rush Elliott.
3. On the Save-Outdoor-Ohio Council: R. W. Franks.

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Bowman, H. H. M.
Burgess, W. M.
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Vaughn, James
Wolford, J. J.
Wright, F. J.

REPORT OF THE FIFTY-SIXTH ANNUAL MEETING OF THE OHIO ACADEMY OF SCIENCE

One of the most successful meetings in recent years was held on the campus of Marietta College on May 1, 2, and 3. This was our first visit to Marietta College and we were certainly well received. The Local Committee had provided for every need. Attendance was above average, and programs were presented by all Sections except J.

The meeting opened with the Council meeting on May 1 and sectional meetings were held on May 2 and 3. The annual banquet on Friday evening at 6:30 was attended by more then 200 members and friends. Dr. P. J. Seyler, of the Local Committee, served as an able toastmaster. Greetings were extended by President W. A. Shimer of Marietta College, and response was given for the Academy by Dr. N. W. Hoerr.

The presidential address by Dr. H. H. M. Bowman was on the subject of Antibiosis, in which a review of the history, the preparation of, and the current uses of Antibiotics were presented.

Dr. F. H. Krecker presented plans of a committee appointed last spring to reorganize and reactivate the Junior Academy.

The annual report of the Secretary was presented and this carried an announcement of the election of new members and of the following persons as fellows:

R. C. Allen
S. S. Arnim
R. G. Bossert
Sears Crowell, Jr.
Chas. A. Dambach
W. A. Dreyer
W. A. Everhart
J. O. Fuller
H. S. Greene
W. K. Hale
P. D. Harwood
D. L. Leedy
C. E. MacQuigg
E. F. Paddock
H. G. B. Robinson
E. J. Schaefer
G. L. Stahly
J. R. Van Pelt, Jr.

The announcement was made of the election of Dr. F. O. Grover, of Oberlin, as an Honorary Life Member.

Two amendments to the By-Laws of the Constitution were read by the Secretary and approved by the Academy. (These are referred to in the report of the Council.)

The report of the Nominating Committee was presented by Dr. L. F. Edwards in the absence of Dr. George W. White, and the report of the Resolutions Committee was given by Dr. Nicholas Mogendorff.

Respectfully submitted,

Rush Elliott, *Secretary.*

REPORT OF THE EXECUTIVE COMMITTEE AND COUNCIL

The Executive Committee met on January 17 and again on May 1 and the Council on January 18 and again on May 1.

Two amendments to the By-Laws of the Constitution were received and passed. One is to Chap. III, Sec. 2, a, to read as follows: "A single payment of $100.00 shall excuse a member from all future annual dues and he becomes a Life Member." The other to Chap. IV, 2b, to read as follows: "The Academy shall pay the Ohio Journal of Science the amount of the bill submitted annually for the printing of the annual report and of the presidential address." These amendments were then presented at the annual meeting. (See Report of Annual Meeting.)

The following items relative to finances are of interest: (1) The Treasurer was authorized to invest $200.00 from the Research Fund in a G-bond, the income to be used for research; (2) The Treasurer was instructed to invest $500.00 of current assets in G-bonds.

Reports from all committees were received and are published as a part of the Annual Proceedings.

The report of the Membership Committee is of particular interest. On account of the unusual activity of this committee, 183 new members were added since the last annual meeting. This is probably an all-time high. The applications were duly accepted. Nominations for Fellowship were presented and approved. (See Report of Annual Meeting.)

The Executive Committee presented the name of F. O. Grover for election to Honorary Life Membership. Election was unanimous.

President H. H. M. Bowman presented an invitation to the Academy to hold its 1948 annual meeting at the University of Toledo. The invitation was enthusiastically received and accepted.

Respectfully submitted,

RUSH ELLIOTT, *Secretary.*

REPORT OF THE TREASURER

COLUMBUS, OHIO, July 15, 1947.

To the Ohio Academy of Science:

I submit herewith a financial statement of the condition of the Ohio Academy of Science as of December 31, 1946. The books have been audited and the opinion of the auditor is herewith attached.

Respectfully submitted,

WILBUR M. TIDD, *Treasurer.*

OHIO ACADEMY OF SCIENCE BALANCE SHEET

As at December 31, 1946

ASSETS

CURRENT EXPENSE FUND:		
Cash in Bank		$1,096.14
Bonds owned:		
U. S. War Savings Bond Series F (cost)	$ 111.00	
U. S. War Savings Bond Series G (cost)	1,400.00	
Total Bonds Owned		1,511.00
Total Assets—Current Expense Fund		$2,607.14
RESEARCH FUND:		
Cash in Bank	$ 410.45	
Banc-Ohio Securities Stock	437.50	
Bonds owned:		
Fort Hayes Hotel, Columbus, Ohio (cost)	$1,300.00	
U. S. War Savings Bond Series G (cost)	100.00	
Total Bonds Owned	1,400.00	
Total Assets—Research Fund		2,247.95
TOTAL ASSETS		$4,855.09

LIABILITIES AND NET WORTH

CURRENT EXPENSE FUND:		
Liabilities—		
Accounts Payable		$ 15.00
Deferred Credits—		
1947 Dues Collected in 1946		32.50
Total Liabilities and Deferred Credits		$ 47.50
NET WORTH:		
Ohio Academy of Science—		
Current Expense Fund	$2,559.64	
Research Fund	2,247.95	
Total Net Worth		4,807.59
TOTAL LIABILITIES AND NET WORTH		$4,855.09

OHIO ACADEMY OF SCIENCE STATEMENT OF INCOME AND EXPENSE
For the Year Ended December 31, 1946
CURRENT EXPENSE FUND

INCOME:		
Dues from Membership—		
Regular		$1,372.00
Life Memberships		75.00
Total Dues		$1,447.00
Grants for Research		69.50
Sale of Publications		28.61
Interest on Bonds		17.50
Total Income		$1,562.61
OPERATING EXPENSES:		
Subscriptions—Ohio Journal of Science	$760.50	
Printing Proceedings	155.46	
Research Grants	69.50	
Postage and Office Supplies	88.07	
Clerical Expense	5.50	
Secretary's Honorarium	100.00	
Auditing Expense	15.00	
Bond of the Treasurer	5.00	
Safety Deposit Box Rent	3.60	
Bank Charges	9.25	
Total Operating Expenses		1,211.88
EXCESS OF INCOME OVER EXPENSES		$ 350.73

AUDITOR'S CERTIFICATE

COLUMBUS, OHIO, June 15, 1947.

The Ohio Academy of Science, Columbus, Ohio.

GENTLEMEN:

In accordance with your instructions I have examined the accounts and records of the Ohio Academy of Science for the year ended December 31, 1946.

I hereby certify that in my opinion the books and records kept on a "cash basis" are in accordance with accepted accounting principles.

In my opinion the accompanying Balance Sheet and Statement of Income and Expense for the Current Expense Fund fairly presents the financial condition of the Ohio Academy of Science as at December 31, 1946, and the results of operations for the year ended at that date.

Respectfully yours,

D. M. SHONTING,
Certified Public Accountant.

REPORT OF THE TRUSTEES OF THE RESEARCH FUND

In connection with this report we have to recognize the death of one of the members of the Board, Professor M. E. Stickney, who died since the last meeting. Professor Stickney, long a member of the Academy, was very faithful in service to the Board and though in serious condition from ill health was constant in attention to the duties of the Board.

Grants during the year 1946 have been completed to Doctor M. T. Sturgeon and Doctor H. T. Gier, both of these being allotted from the grant from the A. A. A. S.

The financial statement by the Treasurer, Doctor Tidd, shows that at the end of the year and detailed in his report, $410.45 was credited to the Research Fund of the Academy, and by action of the Executive Committee $200.00 of this amount was to be invested in Government bonds. This leaves a balance of $210.45 available for grants during the coming year, as also the allowance from the A. A. A. S., which may be approximately $150.00.

It may be mentioned that a grant of $100.00 was allotted to Dr. E. Lucy Braun, this being allotted previous to her designation as a Trustee to fill out the unexpired term of Professor Stickney.

Respectfully submitted,

(Signed, Trustees) E. LUCY BRAUN,
J. ERNEST CARMAN,
HERBERT OSBORN, *Chairman.*

REPORT OF THE LIBRARY COMMITTEE

The sales of publications for 1946 including sales tax amounted to $23.04. Thirty-seven copies of fifteen Special Papers and one Annual Report were sold in seventeen sales. Disbursements consisted of $21.00 to the Treasurer of the Academy and 49 cents for 50 sales tax stamps, leaving a balance at the end of the year of $1.55. This has since been given to the Treasurer, together with two checks totalling $21.40 on the sales for 1947.

It was reported last year that the addresses of the foreign exchanges were being replaced on the mailing list of the Ohio Journal of Science as fast as mail service for periodicals was resumed with the various countries and that the back volumes of the Journal had been sent to 151 addresses during the summer of 1945 and would be sent to 64 more in 1946. This was done and the exchange situation is now nearly back to normal. Requests have come frequently from the foreign exchanges for various issues of the recent volumes of the Journal to complete their sets. Such requests are always fulfilled.

The need for a cumulative index to all the volumes of the Ohio Journal of Science and the Ohio Naturalist has been apparent for several years. Work on it was begun last summer, was necessarily discontinued last Fall, but it is hoped that it can be completed and published in 1948.

The length of service of the present librarian of the Academy has now become of age, for it began exactly twenty-one years ago this Spring. As that would seem to be long enough for one person to have the position it might be well for the members of the Council to refer to the Constitution and to consider who would be the logical one to be appointed when the time actually arrives that will make such action necessary.

Respectfully submitted,

ETHEL MELSHEIMER MILLER, *Chairman.*

REPORT OF THE JOINT ADMINISTRATIVE BOARD OF THE OHIO JOURNAL OF SCIENCE

The annual meeting of the Joint Administrative Board of the Ohio Journal of Science was held at Columbus, Ohio, April 24, 1947. The meeting was called to order by Chairman Snyder. Present were Drs. Snyder and White, representing the Ohio State University, and Drs. Blaydes and Miller, representing the Ohio Journal of Science. Drs. Evans and Anderson were unable to attend.

The minutes of the preceding meeting were read and approved.

Upon a motion by Dr. White, which was seconded by Dr. Snyder, Drs. Blaydes and Miller were elected Editor and Business Manager, respectively, for the year 1947-48.

Dr. Blaydes was called upon for the editor's report, a copy of which is herewith attached. A review of the papers presented in Volume 46 followed in which Dr. Blaydes called attention to the wide distribution of several prominent manuscripts published in the Journal during the past year. The editor called to the attention of the Board that the Ohio Journal of Science is available for immediate publication. He is desirous that this information be conveyed to the Council and through the Council to the membership of the Academy.

The Board expressed general approval to the suggestion of the editor, that short papers and notes on current topics be accepted for publication. Dr. Snyder moved the acceptance of the editor's report; this motion was seconded by Dr. Miller, and passed by the Board.

The Chairman next called for a report from the Business Manager. Dr. Miller's report was in the form of a financial statement for Volume 46 of the Ohio Journal of Science, a copy of which is herewith attached. In commenting upon the financial statement, Dr. Miller again directed the attention of the Board to the continued increase in publication costs. The financial statement clearly indicates that if the Journal is to be continued (on the basis of present costs) additional revenue must be provided. As an example:

Printing cost has increased *this* year over *last* year from $2,022.24 to $2,553.43—an increase of $531.19. The Academy, during the past year, contributed $859.50, $277.19 less than the preceding year. (The average Academy appropriation over the past six years is $1,004.87.)

Two items in the financial report were especially cited to the Board, namely, through the efforts of Dr. Blaydes, and the cooperation of Sectional Chairmen, the Journal received $499.54 in publication subsidy. In addition to this amount, $201.08 was received through credit on reprints of several outstanding papers. Notwithstanding this new source of revenue amounting to $700.62, the Journal experienced a net operating loss of $287.43 for Volume 46.

Dr. Miller, at this point, made it clear that similar subsidy was not indicated for the current volume.

At the conclusion of the Business Manager's report it was determined by the Board to request of the Academy additional subsidy, at least equal to that provided by the University. Additional revenue through accepting advertising was discussed but no action taken.

Dr. White moved the acceptance of the report of the Business Manager; this motion was seconded by Dr. Blaydes and passed by the Board.

Drs. Snyder and White were appointed by the Board to audit the accounts of the Journal for the fiscal year just ended.

There being no further business to come before the Board it was adjourned.

Respectfully submitted,

JOHN A. MILLER,
Secretary of the Board.

THE EDITOR'S REPORT TO THE JOINT ADMINISTRATIVE BOARD OF THE OHIO JOURNAL OF SCIENCE

The Ohio Journal of Science, Volume 46, 1946:		
Total number of pages printed in Volume 46		344
Number of papers in Volume 46		52
Distribution of papers by subject:		
Botany	3	
Entomology	12	
Genetics	1	
Geography	1	
Geology	4	
Medicine	27	
Ohio Academy of Science, Annual Report	1	
Zoology	3	
Total	52	papers
Book Reviews	8	

FINANCIAL REPORT OF THE OHIO JOURNAL OF SCIENCE—FISCAL YEAR 1946

RECEIPTS

Balance from 1945	$ 539.08
University Allowance	1,000.00
Ohio Academy of Science—pro rata of dues	760.50
Ohio Academy of Science—Payment of previous obligation (1943)	99.00
Subscriptions	131.00
Sale of back numbers	87.80
Author's Payment of Plates	56.18
Four Continent Book Co. (change from domestic to foreign rate)	1.75
Graduate School, O. S. U. (Harley Brown paper)	224.54
O. S. U. Medical Symposium Number	200.00
E. L. Moseley paper	75.00
Credit on reprints (Spahr and Glenn)	201.08
	$3,375.93

EXPENDITURES

Spahr and Glenn (printing, Volume 46)	$2,553.43
Bucher Engraving Company, (Volume 46)	351.89
Postmaster (Unpaid balance of 1945)	34.90
Postmaster (Foreign exchanges)	62.80
Postmaster (Current volume)	100.75
Bank charges	.51
Clerical assistance	20.00
	$3,124.28
Balance on hand, March 1, 1947 (Huntington National Bank)	251.65
	$3,375.93

REPORT OF THE COMMITTEE ON CONSERVATION

The Committee on Conservation presents the following report:

1. There is need for more extensive surveys of the natural resources of Ohio.
2. There is need for better correlation of the several surveys of Ohio's natural resources.
3. There is need for an integrated attack upon the problems presented by those who seek to promote public acceptance of the facts about our natural resources and their wise use which are revealed by research.
4. There is need for attack on the problems inherent in gaining administrative use of the facts revealed by scientific research.

The Committee on Conservation recommends that the Ohio Academy of Science should proffer its services, as an organization, and as individuals who are influential in guiding public thinking in many Ohio Communities, toward promoting the more efficient administration of Ohio's natural resources by helping to meet these needs.

Respectfully submitted,

G. W. Conrey, E. W. E. Schear,
C. L. Dow, C. E. Taft,
Roscoe Franks, G. W. White,
Arthur Harper, E. L. Wickliff,
T. H. Langlois, *Chairman.*

REPORT OF THE COMMITTEE ON NECROLOGY

The Committee on Necrology reports with deep regret the death of three members of the Academy since the last annual meeting. The following biographical material was furnished by colleagues on the respective university faculties.

Malcolm Enos Stickney

Malcolm Enos Stickney, professor-emeritus of botany at Denison University, died of coronary thrombosis at his home in Granville, June 15, 1946, after an illness of several months. He had been in failing health during the past few years.

Born April 18, 1874, in Brownville, Me., he attended high school there, later graduating from Nichols Latin School. He took a Bachelor of Arts degree from Bates College in 1898 and the next two years attended Harvard University, earning both Bachelor and Master of Arts degrees there. He did further graduate study at the University of Wisconsin and at the Marine Biological Laboratories, Woods Hole, Mass. Joining the faculty at Denison in 1903, he served one year as instructor, five as assistant professor, and was professor and head of the department from 1909 until his retirement in 1940. For 20 years he taught at the Ohio State Biological Laboratories at Put-In-Bay on Lake Erie. He also served for many years as examiner for the health department of Licking County, making bacteriological diagnoses, and laboratory tests and examinations for local physicians. After his retirement and before his health failed, he spent many hours in the laboratory identifying specimens in the world-wide collection of ferns bequeathed to the college by the late Wallace Cathcart, who had been an alumnus and trustee.

Professor Stickney was a member of several learned and scientific societies, including the American Association for the Advancement of Science, the Botanical Society of America, the Ecological Society of America, the American Microscopical Society, and the Botanists of the Central States. He served the Ohio Academy of Science as vice-president for two years and the Denison Scientific Association as president for two years. At the time of his death he was a Trustee of the Research Fund of the Ohio Academy of Science. He was a member of Kappa Sigma fraternity and of Phi Beta Kappa, national scholastic honorary fraternity.

Francis J. Molz

Dr. Francis J. Molz, S.M., associate dean and head of the division of science at the University of Dayton, died unexpectedly September 3, 1946, of a heart attack.

A native of Baltimore, Md., Dr. Molz joined the Society of Mary in Dayton in 1907, and made his first profession of vows March 25, 1908. He received his Bachelor of Science degree from the University of Dayton in 1916 and a licentiate in science and a Doctor of Philosophy degree from the University of Fribourg, Switzerland, in 1923 and 1924. He joined the faculty of the University of Dayton in 1924 and began teaching in the biology department which he later headed. Dr. Molz was faculty adviser of Sigma Delta Pi, pre-medical society and also a member of the university athletic board. Dr. Molz became associate dean and head of the division of science in 1935. During his term and under his leadership the university completed arrangements for affiliation with St. Elizabeth's Hospital School of Nursing, and also the Miami Valley Hospital's medical technology school and laboratory. The department of home economics at the university was also established as a section of the science division during Dr. Molz's administration.

Brother Molz was a member of the American Association for the Advancement of Science, Ohio Academy of Science, and Ohio Health Association.

Joseph Harvey Gourley

Joseph Harvey Gourley, professor and head of the department of Horticulture and Forestry at Ohio State University, died on October 27, 1946.

Born July 1, 1883, in Homer City, Pa., he received the degrees of Bachelor of Science and Master of Science from Ohio State University in 1908 and 1915, respectively. The degree of Doctor of Philosophy was conferred upon him by the University of Chicago in 1931. He was long associated with the Ohio Experiment Station, holding the position of Chief of the Department of Horticulture from 1921 until his death. He also held professorships in Horticulture

at West Virginia University and at the University of New Hampshire and from 1912–1920 was vice-director of the New Hampshire Experiment Station. In 1929 he became professor and head of the Department of Horticulture and Forestry at the Ohio State University.

Dr. Gourley was Associate Editor of the American Fruit Growers Magazine, a member and former president of the Society of Horticultural Science, and a fellow of the Ohio Academy of Science. His chief professional interests were in the fields of fertilization in orchards; flower-bud formation; pomology; and orchard management.

Respectfully submitted,

A. C. ANDERSON,
F. G. DETWEILER,
R. V. SINNETT, *Chairman.*

REPORT OF COMMITTEE ON RESOLUTIONS

Be it Resolved, that, since the reduction in the budget of the Department of Interior endangers the program of conservation research, the Ohio Academy of Science convey to the proper authorities through its Secretary the urgency of continuing support of this program as now organized in the State of Ohio.

Be it further Resolved, that the members of the Academy express their gratitude and appreciation to President Shimer and to the faculty of Marietta College for the hospitality and courtesies extended; and

Be ir further Resolved, that the members of the Academy express their indebtedness to the local Committee on Arrangements, which under the leadership of Professors H. R. Eggleston and P. J. Seyler has provided such excellent facilities for the meeting, and which has made our stay at Marietta most comfortable and pleasant; and

Be it further Resolved, that the Ohio Academy of Science express to its librarian, Mrs. Ethel Melsheimer Miller, its deep appreciation and gratitude for her devoted service during the past twenty-one years.

Be it further Resolved, that the members of the Academy express their sincere thanks to their President, Dr. H. H. M. Bowman, whose untiring efforts contributed greatly to make this fifty-sixth annual meeting a success.

Respectfully submitted,

N. L. HOERR,
E. W. E. SCHEAR,
N. MOGENDORFF, *Chairman.*